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A 182-FT. CHIMNEY OF REINFORCED CONCRETE AT BELLEVUE, MICH.

A tall chimney of reinforced concrete has recently been built for the Burt Portland Cement Co., of Bellevue, Mich., and presents some interesting features in this class of construction. The chimney is 181-ft. 11 ins. high over all, including the foundation. The foundation was excavated to the limestone bed-rock, and is 23 ft. square and about 5 ft. high. From the ground level to the shoulder, 60 ft. above, there are two concentric walls; the interior diameter is 8 ft. and the inner wall is 4 ins. thick, then there is a 4-in. air space followed by an 8-in. outer wall. The inner shell acts as a lining, and is free to expand and contract. At the shoulder, the outer wall is drawn in to unite with the inner wall, and the thickness above this point is 5 ins. The structure is monolithic throughout, and the maximum compression on the concrete is about 480 lbs. per sq. ft. It was designed to withstand a wind pressure of 50 lbs. per sq. ft., or a velocity of 100 miles per hour. In the accompanying illustrations, Fig. 1 is a view of the work in progress, showing the bars, template ring and the concrete forms in place.

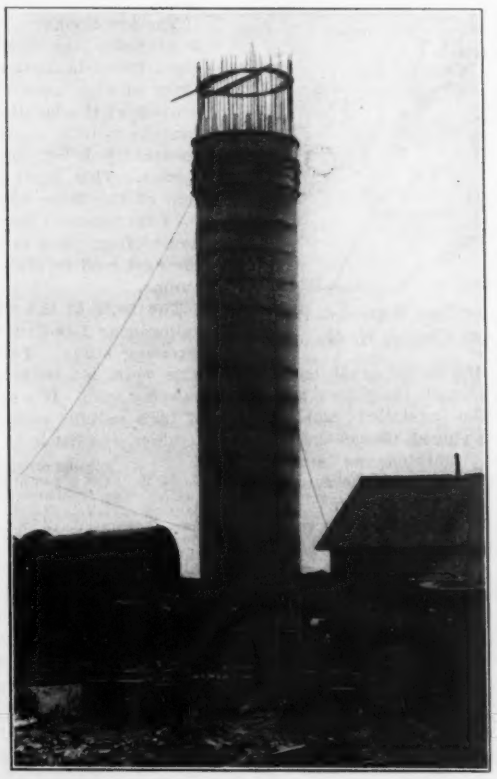

Fig. 1. View of Lower Part Under Construction.

Fig. 2. View of Completed Chimney.

CHIMNEY OF REINFORCED CONCRETE FOR THE BURT PORTLAND CEMENT CO., BELLEVUE, MICH.

Weber Steel-Concrete Chimney Co., Chicago, Builders.

The reinforcement is on the Weber system, using light steel bars of T section. In the foundation, horizontal cross bars are placed 1 ft. apart, about 1 ft. above the rock. At the base there are 108 vertical bars 1¼ × 1¼ × 3-16 in. (54 bars in each wall). These bars extend to the rock and are bent outward at the bottom; the bars of the inner wall run nearly to the rock before being bent, but those of the outer wall are bent just below the base of the chimney. At a height of 10 ft. above the grade line 12 bars were allowed to stop, the other 96 bars being continued by other bars lapping the ends of the lower bars by 2 ft. At other 10-ft. intervals, 12 more bars are stopped, leaving 60 bars to be lapped and extended to a height of 75 ft. above grade, all being drawn in to the 5-in. wall at the shoulder (60 ft. above grade). From the 75-ft. elevation, 48 bars are extended to 90 ft., 36 bars to 105 ft., 24 bars to 120 ft., and the remaining 12 bars run to within a few inches of the top. At intervals of 3 ft., each circle of vertical bars is bound by hoops of T bars 1×1×⅛ ins., but above the 60-ft. elevation these hoops are placed 18 ins. apart. At the lower part of the chimney the vertical bars are not spaced equally, but in groups, to accommodate the flanges of the outer form of the inner wall. Above the shoulder (at 60 ft.) all the bars are equally spaced. The bars that would run through the middle of the flue or breeching hole are cut off, and those near the sides of the hole are bent aside to clear the opening, and then drawn in again. About 12 ft. above the ground are 12 holes in the outer wall, admitting air to the air space; below the shoulder are similar holes to allow for circulation of the air.

The foundation concrete is composed of 1 part "Egyptian" Portland cement, 2 parts sand and 4 parts coarse gravel; above the grade line the concrete is composed of cement and sand only, in proportions of 1 to 3. No section of concrete was allowed to set for more than 24 hours before the next section was built. Two sets of forms were used on both the inner and outer walls. The forms were 3 ft. high, and for the double walls one form a day was filled; for the single wall above the shoulder, two forms a day were filled. Strips on the inside of the forms made the ornamental fluting shown in the view of the finished chimney, Fig. 2. When the work was finished, the chimney was given two coats of a wash composed of cement and water to cover the form marks. The work was commenced on May 28, and completed July 30, 1904.

The foundation weighs 267,815 lbs.; the chimney proper, 471,000 lbs.; total weight, 738,815 lbs.; total weight of steel used, 22,100 lbs. The chimney was built by the Weber Steel Concrete Chimney Co., of Chicago, under the direction of Mr. O. Button, engineer for the cement company. Mr. Button states that the design was developed from actual practice and is excessively strong; but thinks that further calculations will result in less steel being used. He does not think the air space was necessary in this case, owing to the low temperature of the waste gases, which is due to the use of a revolving breeching (connecting the boilers with the chimney) in which the coal is dried ready for pulverizing and blowing under the boilers. For temperatures in the chimney over 1,000° F. however, Mr. Butler would use a 4-in. firebrick lining.

SEVEN CAR-FERRY LINES are now operated by the Pere Marquette Ry. as follows: Ludington, Mich., to Milwaukee, Manitowoc and Kewaunee, Wis.; Windsor, Ont., to Detroit, Mich.; Sarnia, Ont., to Port Huron, Mich.; Rondeau, Ont., to Conneaut, O., and Port Stanley, Ont., to Conneaut, O. The lines from Conneaut are operated in connection with the Bessemer & Lake Erie Ry.

TESTS OF IRRIGATION PUMPING PLANTS AND WELLS IN THE VALLEY OF THE RIO GRANDE.

By Chas. S. Slichter.*

The accompanying table shows the results of tests of a number of pumping plants used for irrigation, and situated in the valley of the Rio Grande in the lower part of New Mexico and the western end of Texas. Most of the entries in the table explain themselves. The first three pumping plants are located about three miles east of El Paso, Tex. The next three are located in the valley of the Rio Grande about eight miles east of El Paso, Tex. The plants of Barker, Boyer, Burke, Carrera, Hager, Hines, Roualt, Totten, and the Agricultural College, are located in the valley of the Rio Grande in the neighborhood of Las Cruces, N. M. The pumping plants of the Horaco Ranch Co. are located near the Post Office of Berino, N. M., which is situated 24 miles north of El Paso and 17 miles south of Las Cruces.

The fuel used in most of these pumping plants is gasolene, which term as here used includes the "distillate" manufactured from the Texas crude oil, which is extensively used for fuel purposes. Its calorific value is somewhat less than that of the gasolene used in the Eastern States.

DETERMINATION OF VACUUM.

In all of the pumping plants, except the one of E. J. Hadlock, water was recovered by means of centrifugal pumps, which in nearly all cases were directly coupled to the top of the well casings. In order to determine the suction of the pumps, it was necessary to drill a hole in the goose neck of the centrifugal pumps and insert the vacuum gage. The measurements to determine the distance the pumps were obliged to lift the water were made from this vacuum gage tap as datum in all cases. The total lift of the pump can be found in each case by adding the corresponding numbers in Columns 6 and 7. In Column 8 is given the distance that the natural level of the water in the well is lowered during pumping. If the vacuum gage had been placed at the exact level of the undisturbed ground water, the readings in Column 8 would be identical with those in Column 7. The numbers in Column 8 are less than those in Column 7, because in all cases the vacuum gage stood some distance above the natural level of the water in the well.

SPECIFIC CAPACITY.

The numbers in Column 11 express the readiness with which the well furnishes water to the pump. The numbers in each case were found by dividing the numbers in Column 10 by the corresponding numbers in Column 8; these numbers, therefore, express the amount of water the well would furnish if the water level in the well was lowered but 1 ft. These numbers constitute what is known as the "specific capacity" of the well, and are large in case of a good well and small in case of a poor well.

In Column 12 there are given the same magnitudes as are expressed in Column 11, reduced in each case to one square foot of well strainer. The numbers in this column, therefore, express the amount of water in gallons per minute furnished by one square foot of well strainer under a head of 1 ft. of water. They are a numerical expression of the degree of coarseness of the material in which the well is placed.

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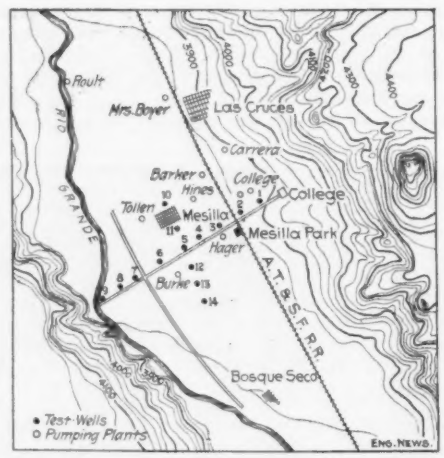
COST AND OPERATING EXPENSES.

In Column 13 are given the costs of the various plants expressed in round numbers. These are in most cases an estimate at the rate of $100 per HP. for the total cost of engine, pump and wells. In a few special cases the cost is at a higher rate than the above. In estimating the expense of operating the various plants, the depreciation in the total value of the plant has been taken at 10%, and the rate of interest at 8%. It is difficult to make an accurate estimate of the amount of cost that should be charged up to the water recovered by an irrigation plant, on account of the presence of several unknown factors. If the plants were in operation every day in the year it would be relatively easy to make an accurate estimate of these factors in the operating expense; as it is, the plants are in operation for a longer or shorter period depending upon circumstances which vary from year to year. Most of the plants are used merely as an auxiliary to the supply of ditch water. In making the estimate of the charge for interest and depreciation I have estimated that the plants are in operation for 2,000 hours each season. This corresponds to a continuous use of three months of 24 hours daily, or 200 days of 10 hours each. It probably represents a fair average of the actual conditions. The intermittent manner in which the plants must be used, together with the unskilled hands into which the machinery is placed, makes the charge for depreciation and maintenance unusually heavy. It is to be compared with the rate of depreciation on ordinary farm machinery.



Map Showing Location of Test Wells and Pumping Plants Near Las Cruces, N. M.

In Column 15 there is given a charge for labor and other expenses, including oil, batteries, and such other incidental expense as is not properly included under the head of depreciation. The operation of the gasolene plants can easily be put in charge of unskilled labor, and for the smaller plants full time is not required of such labor.

FUEL COST.

That part of the operating expense which is properly chargeable to fuel cost can be accurately determined. (See Columns 5, 16, 17 and 18).

COMMENTS ON THE RIO GRANDE PUMPING PLANTS.

The pumping plants of Martinez, French, Hadlock, Smith and Porcher are all located in the bottom lands of the Rio Grande River, from three to eight miles east of El Paso, Tex. From Column 12 of the table, it will be seen that the specific capacities of the wells per square foot of well strainer are nearly the same at the plants of Martinez, French, Smith No. 2 and Porcher, varying only between 1.21 gallons a minute at Martinez's well to 1.37 at French's well. These numbers, it should be remembered, give the amount of water furnished by each square foot of well strainer for one foot head of water. The numbers express, therefore, the degree of coarseness of the material in which the strainer is placed, provided, of course, that the well strainers themselves offer little or no resistance to the admission of water to the well. The specific capacity per square foot of strainer at the Smith plant No. 1 and the Hadlock plant is much smaller than the others. In the case of the Hadlock well, there is no doubt but that this result is due to the fact that three of the Hadlock wells draw from surface water above a clay which overlies the sand and gravel from which the fourth well and the neighboring wells of Martinez and French draw their supply. In addition to this, the strainers on these three wells of Hadlock consists of nothing but common pipe drilled with small round holes. This poor form of strainer is sufficient in itself to cut down very materially the specific capacity of the wells.

The low specific capacity at Smith's plant No. 1 is probably due chiefly to a local deposit of fine-sized water-bearing sand. There is no covering layer of clay over the water-bearing sands and gravels at the location of these wells. The sands contain so little coarse material that fine sand is constantly being drawn into the wells by the pumps. This draft on the sand deposit at the east of the three wells at Smith's plant No. 1 is such that several wagon loads of gravel have been hauled from time to time and placed in the pit of the east well to replace the sand removed by the pumps.

The tests of the nine wells in the Rio Grande valley near Las Cruces, New Mexico, form an interesting study. The relative locations of these nine wells can be seen from studying the accompanying map. If we arrange these wells in order of their specific capacities per square foot of well strainer, the list is as follows:

Name of well.	Specific capacity, gals. per min. per sq. ft. of strainer.	Name of well.	Specific capacity, gals. per min per sq. ft. of strainer.
Carerra	3.530	Totten	.760
Agr. College	2.780	Hager	.760
Boyer	1.969	Barker	.337
Hines	1.790	Roualt	.337
Burke	.930		

By consulting the map it will be observed that the first three of these wells are located near the eastern edge of the river valley, and the high specific capacity of the wells is undoubtedly due to

TESTS OF PUMPING PLANTS FOR IRRIGATION IN THE VALLEY OF THE RIO GRANDE, NEW MEXICO AND TEXAS.

(1) Name of plant.	(2) Nearest post-office.	(3) H.P.	(4) Fuel used.	(5) Price of fuel.*	(6) Lift above vacuum, ft.	(7) Vacuum in ft. of water.	(8) Amount water is lowered, ft.	(9) Total lift, ft.	(10) Yield galls. per min.	(11) Specific capacity gal. per min. Actual.	(12) Per sq.ft strainer.	(13) Cost of plant.	(14) Int. and depreciation per hr.	(15) Labor and other cost	(16) Fuel cost per hr.	(17) Fuel cost 1000ft. gall., cts.	(18) Fuel cost per acre ft.	(19) Total cost per acre ft.
Felix Martinez	El Paso, Tex	10	electricity	.05	16.77	25.50	22.16	38.93	378	17.50	1.21	$1,200	$ .108	$ .050	$ .243	1/4	$3.43	$5.75
W. N. French	El Paso, Tex	8	gasolene.	.14	12.65	18.05	13.35	30.70	269	20.20	1.37	800	.072	.120	.112	1/4	2.26	6.13
E. J. Hadlock	El Paso, Tex	5½	gasolene.	.14	5.20	22.60	13.03	27.80	258	19.80	.792	800	.072	.140	.074	1/4	1.58	6.02
J. A. Smith, No. 1	El Paso, Tex	28	crude oil	.03	14.00	24.90	18.44	38.90	938	50.50	.890	3,000	.270	.180	.0975	1/11	.73	3.17
J. A. Smith, No. 2	El Paso, Tex	22	gasolene.	.14	15.45	26.10	21.00	41.45	1,325	63.20	1.37	2,200	.198	.150	.35	1/4	1.43	2.79
J. S. Porcher	El Paso, Tex	15	gasolene.	.14	12.80	23.07	20.59	35.87	658	32.00	1.28	1,500	.135	.150	.21	1/4	1.73	4.10
F. C. Barker	Las Cruces, N. M.	5	gasolene.	.17	20.18	25.40	22.48	45.58	131	5.83	.337	1,200	.108	.120	.09	1/4	3.73	13.20
E. M. Boyer	Las Cruces, N. M.	12	gasolene.	.17	17.60	22.70	19.76	40.30	658	33.30	1.969	1,200	.108	.150	.163	1/4	1.34	3.47
F. Burke	Mesilla, N. M.	21	gasolene.	.17	14.85	25.60	22.85	40.45	725	31.75	.930	1,800	.162	.150	.34	1/4	2.52	4.87
J. C. Carrera	Mesilla Park, N. M.	8	gasolene.	.17	12.65	14.20	8.48	26.85	648	74.60	3.530	900	.081	.120	.177	1/4	1.48	3.16
W. N. Hager	Mesilla Park, N. M.	12	gasolene.	.17	17.17	17.60	15.20	34.77	325	22.30	.760	1,200	.108	.150	.31	1/4	5.14	9.57
A. L. Hines	Mesilla, N. M.	8	gasolene.	.17	19.05	17.00	14.08	36.05	271	19.20	1.790	800	.072	.120	.255	1/4	5.19	8.95
T. Roualt	Las Cruces, N. M.	10	wood	2.00	8.66	27.50	23.86	34.16	351	10.30	.337	1,200	.108	.180	.223	1/4	3.47	7.91
G. H. Totten	Mesilla, N. M.	28	gasolene.	.17	16.95	26.40	22.50	43.35	464	20.60	.760	2,000	.180	.150	.37	1/4	4.34	8.19
Agr. College	Mesilla Park, N. M.	20	wood	2.25	17.10	12.45	11.37	29.55	1,000	88.00	2.320	1,600	.144	.200	.52	1/4	2.83	4.70
Horaco Ranch Co., No. 1	Berino, N. M.	12	gasolene.	.17	9.71	14.18	13.75	23.89	837	60.80	1.690	992	.090	.090	.16	1/4	1.04	2.21
Horaco Ranch Co., No. 2	Berino, N. M.	12	gasolene.	.17	10.36	24.90	23.64	35.26	191	8.10	.178	992	.090	.090	.204	1/4	5.80	10.90
Horaco Ranch Co., No. 3	Berino, N. M.	12	gasolene.	.17	11.56	20.80	18.55	32.36	750	40.40	.892	992	.090	.090	.16	1/4	1.16	2.46

*The price of gasolene is given in cents per gallon in barrel lots. The price of electricity is given in cents per kilo-watt hour. Cost of wood at the ranch of T. Roualt is the cost of cotton wood per cord. The price of wood at the Agricultural College of $2.25 per cord is the rate for small Tornillo wood, which has a higher caloric value than the cotton wood used by Roualt.

coarse mountain debris, which has been deposited along the eroded edge of the Mesa. The high specific capacity at Hines' plant seems to be exceptional to the general lower average prevailing in the intermediate district lying between the border of the Mesa and the river channel, as is represented by the plants of Hager, Totten, Burke and Barker. The low specific capacity of the Barker well is due in part to its small diameter, and it is to be classed, therefore, with the Burke, Totten and Hager wells rather than with the Roualt well. This last well is close to the river channel. Its low specific capacity is an indication of the progressive fineness of the deposits as we approach the river from the Mesa.

It should be considered that the specific capacities of the first wells named in the above list are exceptionally high rather than that the others in the list are exceptionally low. Even the specific capacity of the Roualt well of over 1-3 gal. per min. per sq. ft. of well strainer would be considered high in many parts of the country.

The specific capacity of the three wells on the Horaco Ranch near Borino, New Mexico, present an interesting study. These plants are located but a few hundred feet apart and are identical in all respects except in the depth of the wells. The wells are 9⅝ ins. in diameter and each has 18 linear ft. of well strainer at the bottom, formed by drilling 1½-in. holes in the 9⅝-in. casing and wrapping the casing with No. 8 galvanized iron wire, leaving ⅛-in. space between. The enormous differences in the specific capacities of these wells is entirely due to the fact that No. 1 is 75 ft. deep, No. 2 is 53 ft. deep, and No. 3 is 62 ft. deep. The small expense necessary to sink well No. 2 from a depth of 53 ft. to a depth of 75 ft. will change the cost of the water recovered from $10.90 per acre-foot to $2.21 per acre-foot.

The group of pumping plants near Las Cruces are for the most part very recently constructed, and changes will undoubtedly be made in many of the plants based upon the experience of the present irrigation season. The wells at the Agricultural College were the first ones constructed in this part of the valley, and an excellent report of tests on these wells, by Professors Vernon and Lester, was issued in April, 1903. The very high specific capacity of the College wells has had its influence upon the construction of the other plants. With a few exceptions, we may say that the pumping plants in the Mesilla valley have engines and pumps entirely too large for the wells, or as may be preferably stated, the wells are too small for the pumps and engines. By comparing the high lifts recorded in Column 9 of the table with the amount of lowering of the water in the wells, which is recorded in Column 8, it will be seen that the lift of many of the plants can be considerably decreased by increasing the amount of strainer surface in the wells. In most cases this will mean the construction of additional wells as the strainer surface cannot be otherwise sufficiently increased. The necessity of keeping the lift of the pump down to a minimum is greatly emphasized in irrigation plants and large strainer surface is the first requisite.

The efficiency of the smaller plants can also be increased by the construction of storage reservoirs or ponds for the accumulation of water before it is used for irrigation. In this way, the duty of the water can be considerably increased. Barker's plant is the only one having such reservoirs. For plants that yield over a second-foot of water, the reservoir is undoubtedly of little additional value.

The determination of the speeds of the centrifugal pumps at the various plants showed that in many cases the speed had not been properly adjusted to correspond to the required lift. In nearly all such cases the speeds were too high. This was undoubtedly due to the fact that the vacuum had never been determined, so that the total lift of the pump was unknown.

DIRECTIONS FOR MAKING CONCRETE-STEEL SLAB CULVERTS AND BRIDGES.*

Stone flagging or concrete slabs supported by steel I-beams or rails should be used in preference to plank for covering culverts having less than eight or ten feet span.

Provide a mixing-bed 8 ft. wide and 10 ft. long formed of smooth boards laid close, or of sheet iron. Never mix mortar or concrete on the ground. Make an open box 6 ins. deep, 2 to 3 ft. wide and from 3½ to 4½ ft. in length, as the span may require. Whenever the necessary width of opening exceeds 3 ft., I-beams of steel must be used to span it, and these must be placed 2 to 3 ft. between centers, this distance varying inversely with the width, and the slabs made to span this distance between the centers of the beams. Provide expanded metal of gage No. 4, formed of steel 3-16-in. thick, 5-16-in. wide, in meshes 6 ins. wide and 12-ins. long and weighing 1.1 lbs. per sq. ft., and costing 3 cts. per pound, and cut into sheets of sufficient size to nearly cover the proposed slabs, being careful that the 12-in. mesh crosses the span, Fig. 1.

To make the concrete, use one part loose Portland cement, two and one-half parts sand and five parts broken stone or gravel not exceeding 1-in. in size, all being measured in loose bulk. If stone from a crusher is used, screen out the fragments larger than 1 in., and use for the concrete all the product less than 1 in., allowing the dust to act instead of one part of sand. If gravel is to be used and is not clean, it should be washed in running water until the water runs away clear. Before using any cement, blend the contents of several bags or barrels—about five—so that if one bag or barrel is poor it will be mixed with four good ones. Thoroughly mix the blended cement and the proper amount of sand before wetting; then add enough water to make a thin mortar which is not thin enough to run; dampen the broken stone or gravel; and then spread the proper quantity of the dampened stone or gravel upon the mixing bed in a 4-in. layer, and cover it with the mortar; mix thoroughly by turning with shovels while working with hoes until all fragments are coated with mortar. The mass thus formed should flatten and quake when put in a wheelbarrow or pail, but should not be fluid. Spread over the bottom of the box a coat of mortar followed by a coat of fine concrete making a layer of 1¼ ins. thick after ramming, and upon this lay the sheet of expanded metal and embed it in the soft concrete by ramming, using care that the 12-in. length of the mesh lies with the length of the span of the slab when it shall be put on the culvert. Fill the box, working the stone from the sides with a trowel so that the edges will have a smooth surface; ram thoroughly until no stones or gravel can be seen and until the wet mortar comes to the top, and also smooth the top with the trowel. Keep this covered from the sun and wet it night and morning for a week until hardened, when it can be easily taken from the box. After it has set for an hour, scratch the word "Top" in large letters in the soft mortar, so that it may surely be thus laid in the work, as the slab will have little strength if laid with the embedded metal up. Do not make concrete in freezing weather, or else make it where it can be protected from frost. Such slabs can be made in winter by making them in a warm place free from frost and storing them for use until they are set and hard.

The flag-stone or concrete-slab cover can be covered by the road material, and if the culvert is properly built there will be no expense for maintenance, as in the case with a plank top. No culvert should be built less than 2 ft. in width so that it may easily be kept free from obstructions at all times. The bottoms of all culverts should be given sufficient fall to send the water out of them quickly. The bottoms, and spaces three or more feet wide at the inlets and the outlets, should be paved to prevent undermining, using flat stones set on edge and close together with the joints filled with coarse sand or fine gravel, or using cobbles properly embedded. The side ditches should also be similarly paved where long grades of 5% or over occur.

For culverts and short bridges having a span of less than 25 ft., it is usually most economical to use steel I-beams, covered with flagstones or concrete slabs.

In order to give proper support to the upper or compression flanges of the I-beams, each beam should be tied to each adjacent beam with ⅝-in. round tie rods spaced not over 5 ft. apart. The centre of these rods should be 2½ ins. below the tops of the beams and the two rods in any line which meet in any beam should be spaced 2½ ins. between centers.†

The concrete slabs, Fig. 2, should be made with a shoulder ½-in. high along each edge, fitting with not more than ⅛-in. clearance against the upper flange of the beam. The boxes in which the slabs are made should be constructed so as to provide these shoulders. The slabs, when finished, will be 5½-ins. thick at edges and 6 ins. thick elsewhere.

All I-beams should receive two coats of good paint. The beams should be carefully cleaned before the paint is applied, and the paint should be well brushed in.

The accompanying table shows the sizes and weights of I-beams which should be used to insure safety in culverts, when crossed by a ten-ton road roller. The fig-

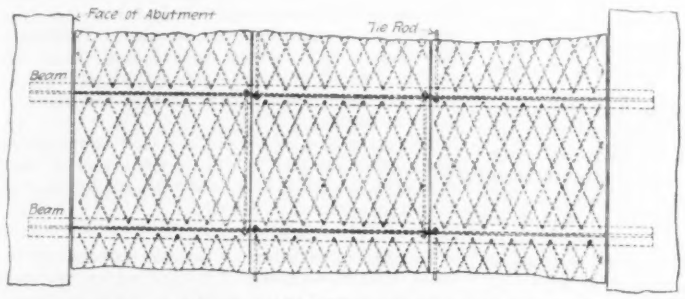


FIG. 1. PLAN OF CONCRETE-STEEL SLAB CULVERT.

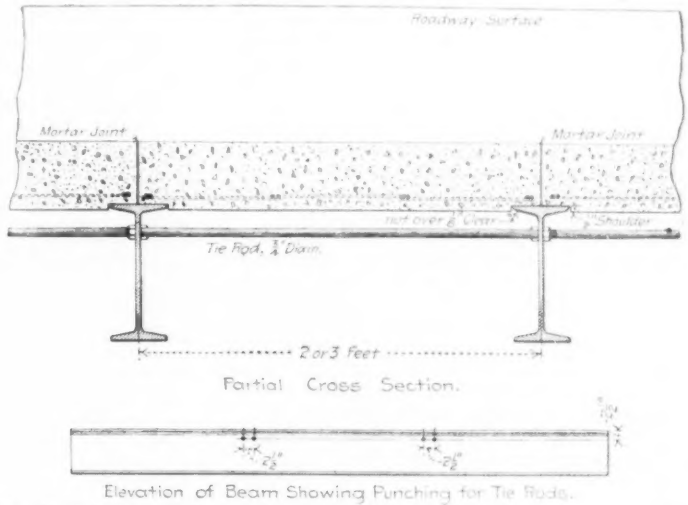


FIG. 2. TYPICAL DETAILS OF I-BEAM BRIDGE WITH CONCRETE-STEEL SLABS.

*Abstracted from "Improvement, Repair and Maintenance of Public Highways," Bulletin No. 7, New York State Engineer, Albany, N. Y.

†It would seem to us that a better detail would be to place these tie rods or spacing rods near the bottom of the beams, since their tops are held stiff laterally by the concrete slabs on top.—Ed. Eng. News.

Table Showing Sizes and Weights of I-Beams to be Used for Various Lengths of Span for Bridges or Culverts, Using Stone or Concrete Slabs.

Depth of I-beam. Inches.	Width of Flange in Inches.	Weight of I-beam per ft. of length Pounds.	Thickness of web of I-beam. Inches.	Limiting Lengths of Span.—I-beams spaced 2 ft. between centres. ft. ins.	Limiting Lengths of Span.—I-beams spaced 3 ft. between centres. ft. ins.
5	**3**	**9⅜**	**0.21**	**4 6**	**3 6**
5	3⅛	12½	0.36	5 0	4 0
5	3⅛	14⅝	0.50	5 6	4 0
6	**3⅛**	**12½**	**0.23**	**6 6**	**5 0**
6	3⅛	14⅝	0.35	7 0	5 6
6	3⅛	17½	0.48	7 6	6 0
7	**3⅛**	**15**	**0.25**	**8 6**	**7 0**
7	3¼	17½	0.35	9 0	7 6
7	3⅜	20	0.46	9 6	7 6
8	**4**	**18**	**0.27**	**11 0**	**8 6**
8	4⅛	20½	0.36	11 6	9 0
8	4⅛	23	0.45	12 0	9 6
8	4¼	25½	0.54	12 6	10 0
9	**4⅛**	**21**	**0.29**	**13 6**	**11 0**
9	4⅛	25	0.41	14 6	11 6
9	4⅛	30	0.57	15 6	12 6
9	4¾	35	0.73	16 6	13 6
10	**4⅛**	**25**	**0.31**	**16 6**	**13 6**
10	4⅛	30	0.46	17 6	14 0
10	4⅛	35	0.60	18 6	15 0
10	5⅛	40	0.75	19 6	16 0
12	**5**	**31½**	**0.35**	**21 0**	**17 6**
12	5⅛	35	0.44	21 6	18 0
12	5¼	40	0.46	22 6	19 0
15	**5½**	**42**	**0.41**	**27 6**	**23 0**
15	5⅝	45	0.46	28 6	23 6
15	5⅝	50	0.56	29 6	24 6

ures in heavy type indicate the economical sizes to use. The lengths given are the clear spans or distances between the side walls. The I-beams should be long enough to rest a foot on each wall. The spaces between and outside of the I-beams on top of the side walls should be filled with concrete or masonry laid in cement mortar. If care is taken to fill with mortar the joints between the flagstones or concrete cover blocks, the I-beams will last many years longer than they will if the drainage from the road is allowed to wet and rust them.

NOTES ON POWER PRODUCTION.

By William McClellan, Ph.D.*

Some time ago a very prominent engineer said that he was not willing to install a large steam-engine plant, or even one of steam-turbines, at the present time because it was very likely that before he could get it started he would be sorry that he had not put in gas engines, so quickly is the latter type developing. Yet, even in face of the fact that steam-turbine contracts are being made nearly every day, and reputable companies are ready to install gas-engines under guarantee, there are some engineers who refuse to consider any type except the steam-engine. When one looks at the enormous investments now being made in steam-engines at probably the largest steam powerhouse in the world (the Interborough powerhouse in New York), it is evident that there is some reason for this attitude, though if the decision in regard to this station were to be made to-day, it is possible that it might be different.

Amid the more or less vigorous discussion that goes on at intervals, one finds it rather hard to keep a well-balanced mind and reserve judgment until the evidence is all in. The chief difficulty, of course, is the difference in the amounts of information that we have in relation to the various sources of power and their applications. Of the steam-engine we know much, of the steam-turbine much less, and of gas and oil engines real knowledge (for most of us) is very meagre indeed, except of the smaller sizes. In the second place our knowledge of steam is largely first hand, which is not true usually for gas and oil. It may be well therefore to sum up in an unbiased way what may be said for the various types in the light of our present knowledge. It should be understood that the writer has in mind plants of not less than 1,000 HP., since the question is a very different one to the small and the large user.

We may classify prime movers as follows:

Steam: (1) Engine. (2) Turbine.
Gas: (3) Engine. (4) Turbine.
Oil: (5) Engine, explosion type. (6) Engine, Diesel type.
Water: (7) Turbine.

Of these we shall discuss only the first three, since the gas-turbine and the oil-engine lack development, particularly in the large sizes, and the water-turbine depends too much upon local conditions and circumstances. The gas-turbine is theoretically the ideal prime mover and when (if possible at all) it is put in practical shape, it will take first place. The Diesel engine as far as it has been developed, that is to 225 HP., makes a remarkably fine showing. How it will succeed in holding its own is still a matter of time.

It seems proper to consider a prime mover from three standpoints: Reliability, Regulation, and Cost, and we shall do so in this paper, and in this order of importance, also, for we must assume that an engineer is willing to pay for reliability and for as much regulation as is necessary.

RELIABILITY.

The reliability of any machine depends equally on two things, proper design and proper operation. So far as design is concerned it is probable that all our types are equally reliable. A faulty design shows itself either in parts failing to function as expected or in breaking. Accidental breaking, except frequent breaking of the same part, will always be possible even in the old reliable steam-engine. For example, the writer has seen two Corliss valve cranks break on different engines during the last year and temporarily throw the engines out of service, yet no person would call the Corliss engine unreliable because such accidents happen at times.

The steam-turbine, owing to its small number of parts, small friction surface, and absence of reciprocating motion, is extremely reliable. Were it not for the close proximity of high temperatures and comparatively high speed bearings, the reliability would be even greater. This proximity means that the bearing is normally very near to a danger point, especially in the smaller and more compact sizes. In one make of turbine where some of the parts have very great speed, the high speed bearing can never be touched by the hand while running, and the slightest failure in the cleanliness, quality, or quantity of the oil means a burn out. Engineers have finally agreed that the famous step-bearing of the Curtis turbine, which aroused so much controversy and misgiving, is quite good design, and recent developments seem to indicate that in the near future oil-lubrication will be a thing of the past in connection with this type.

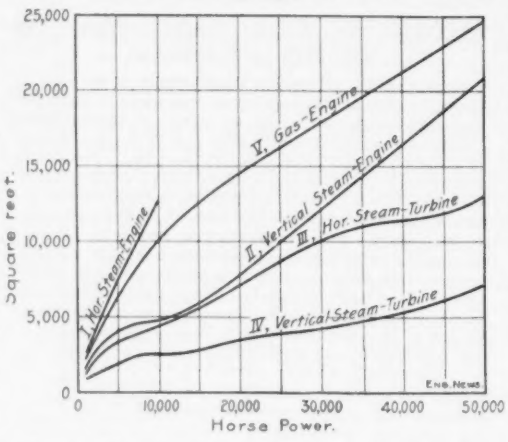


Fig. 1. Diagram of Floor-Space Required for Different Kinds of Prime-Movers, for Various Capacities of Plant.

The gas-engine presents many new difficulties in design, which were not overcome in early engines. Gas-engine cylinders not long ago often cracked on account of the excessive temperatures and pressures, but we almost never hear of this now. The igniter will always be a source of trouble, and for this reason we shall never cease looking for a practical gas-turbine, or slow-burning type of engine, until we find it. This will come, just as the steam-turbine has come. Yet duplicate igniters and proper inspection have done away with the difficulty of ignition entirely. These are the chief troubles that have been observed and it does not seem to be too much to say that with them out of the way the engine is reliable, that is, with proper attention it will not fail suddenly and cause a shut-down.

But here is the sine qua non—proper operation. There is a small army of men who understand all the details of steam operations and are able to detect the first warnings of trouble before it becomes serious. Less than a month ago a prominent operating engineer complained of some noisy steam-turbine pumps because the noise prevented his engineers from hearing the engines talk; "an engineer prevents trouble by using his ears," he said, and he was right. Moreover through years of experience these men have learned a thousand tricks and makeshifts that help them out of tight places. Many of these will serve equally well with the gas-engine, but more will have to be learned. The running engineer, usually of scanty education, having learned almost everything by experience, cannot be taught in a day that clean gas is just as important as dry steam, or even more so; that cooling water is not a mere help as it is in an engine-bearing but an absolute necessity in a gas-engine; and that an igniter like everything else works till it breaks down, but breaks down sooner than some other parts.

The writer considers a gas-engine installation to be thoroughly reliable, but he would be very careful in the selection of his men and would not leave the engines entirely in their hands until he had them well educated. Europe has passed far ahead of us in gas-engine practice, and we hear no talk of failure. The well-known faculty of European engineers for careful operation is responsible for this, for no one will deny that we have several makes of gas-engines in this country that are as good as or better than any made abroad. Many persons are claiming, on the other hand, that a cheaper attendance will be possible in gas-engine practice. If they mean by this a smaller number of men they are undoubtedly right, owing to the smaller number of auxiliaries, but if they mean less intelligent men they are greatly mistaken.

It is more nearly fair to consider the two plants rather than the engines alone. Our steam plant consists of a boiler with a large number of joints under high pressure; a long line of suspended piping under like pressure, and subject to severe expansion strains; a group of pumps, traps, condensers, valves, in conjunction with a complicated exhaust, with which it takes a man a long time to get acquainted sufficiently to do the right thing at the right time. In the gas-engine plant we have a producer and holder with little pressure; a low-pressure pipe line; no auxiliaries except a starting outfit and a very simple exhaust; a plant with large possibilities for storage of power at low cost, and so simple indeed that in all discussions of gas-engine introduction not one attack has been made on any part of the plant except the engine.

To summarize we should say that, given proper operation, any one of the three types of plant is reliable and could be recommended by an engineer for continuous service.

REGULATION.

Regulation applies to prime movers in two ways, that is, to speed of revolution, and to cyclical variation of speed during a single revolution. The latter may be called "variation," the former simply "regulation." Steam-engine contracts now call for a regulation of 1.5% and a maximum variation of 1¼° in phase. That sufficient regulation may be provided in steam-engine plants for the paralleling of alternators, the crucial test of all regulation, is shown daily by a large number of plants.

The steam-turbine is capable of the closest kind of governing, and in a number of tests has shown its superiority. The turbine and gas-engine are opposed in this respect. The former receives its energy in a continuous stream and can be governed at any instant, while the latter, receiving its energy in impulses, becomes a more difficult problem.

There are, generally speaking, four methods of governing gas-engines, viz,—(1) "hit-or-miss," (2) throttling, (3) impoverished charge, and (4) variation of explosion point. The first of these, in which the charge of explosive mixture is entirely cut-off at some periods of admission, is un-

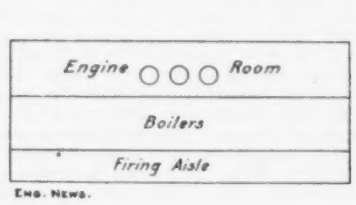


Fig. 2.

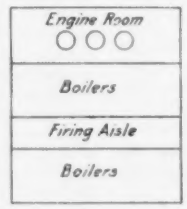


Fig. 3.

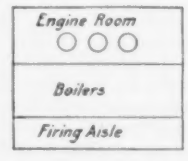


Fig. 4.

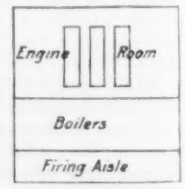


Fig. 5. Station Arrangement Similar to Fig. 4, but for Horizontal Steam Turbines.

FIGS. 2, 3 AND 4. SKETCHES SHOWING THREEWAYS OF ARRANGING A POWER STATION USING VERTICAL STEAM-TURBINES.

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satisfactory for large engines; the fourth is uneconomical; the third is a modification of (1) and is even less desirable. It is probable that throttling will be the method adopted for all gas-engines eventually. Throttling in a gas-engine has none of the objectionable features that the same method has in steam-engine work.

In this country, gas-engines in large sizes have been built after three types, viz,: The three-cylinder single-acting four-cycle type, receiving energy two-thirds of every revolution; the two-cylinder single-acting two-cycle tandem type, receiving energy at every stroke; and the two-cylinder double-acting four-cycle tandem type, receiving energy at every stroke. Double engines are frequently built of the two latter types. Experience has shown conclusively that an engine which receives energy as frequently as every two-thirds of a revolution can be governed sufficiently well for any purpose. Stations might be mentioned that are running alternators in parallel with the above types without trouble. The writer has in mind a large gas engine installation of several years ago where they had considerable trouble with regulation but a change in the governor design removed all trouble.

Since the work is being done every day satisfactorily by steam-engines, steam-turbines and gas-engines, there would seem to be little room for argument on the score of regulation.

COST.

It is very hard to give any figures of cost that are closely approximate for all cases that may come up. There are, in every proposition, peculiar circumstances which cause certain items to increase or decrease in cost and so change the total estimate. Every plant that is to be designed, therefore, must be discussed and settled as an independent proposition. On the other hand there are certain average values, especially if we limit our scope, which will serve as guides as to what we may expect, and may be taken as starting points for more detailed examination.

TABLE I.—Power-Plant Costs.
First Cost, Dollars per Kilowatt.

	Steam Engine.	Steam Turbine.	Gas Engine.
Building and foundation.....	$12.00	$6.00	$10.00
Auxiliaries and piping.....	8.00	6.00	included in engine
Engine and generator.....	32.00	30.00	74.00
Total.....	52.00	42.00	84.00
Boiler room or producer shed (including pumps, heaters, piping, economizer and stack).....	12.00	12.00	included above
Boiler and stoker (erected)...	14.00	14.00	20.00
Total.....	26.00	26.00	20.00
Grand total of first cost per kilowatt.....	78.00	68.00	104.00
Operating Cost, Dollars per Kilowatt-Year.			
Fixed charges, 15% of cost...	$11.70	$10.20	$15.60
Labor.....	6.20	5.75	4.40
Oil.....	1.50	.60	1.80
Coal.....	14.60	14.60	7.30
Total of operating cost per kilowatt per year.....	34.00	31.15	29.10

Notes: Capacity of each plant, 4,500 KW. in three 1,500-KW. units.
Interest, depreciation and taxes, 15%.
One year = 7,300 hours (365 days of 20 hours).
Load, electric railway of 50% load-factor.
Cost of coal, $2.25 per ton of 2,240 lbs.
Two engine HP. = one boiler HP.

In the accompanying Table I. the writer has arranged a table of comparative costs, representing present prices for labor and material and quotations from manufacturing companies. The figures apply to the following plants: (1) A steam-engine plant, consisting of a compound Corliss engine running condensing, without superheat, and supplied with steam by horizontal water-tube boilers with cast-steel headers: (2) a steam-turbine plant under the same conditions as the steam-engine plant; (3) a gas-engine plant with horizontal gas engines and Taylor producers. Other data are given in the table, and in the following is a discussion of the various items.

LOT AND BUILDINGS.—A desirable spot for a powerhouse always costs considerable money. It may on account of distribution requirements have to be in the settled portion of town where land is high, though an engineer will consider matters a long while before settling where he will haul every pound of coal in carts, and buy every pound of water. This illustrates a point in question. In Philadelphia, if using city water, a 6,000 KW. station on railway load would require about $3,000 worth of boiler water. To run condensing, if in the center of town, an expensive cooling-tower plant is necessary, as enough city water would cost about $50,000. All this would be entirely avoided if the location were near a body of water. On the other hand, desirable river sites are not low priced. No values can be given.

When we come to consider relative amounts of space required for different types of plant, we have an interesting problem. In a paper by Mr. E. H. Sniffen (Am. St. Ry. Assn., 1902), several interesting curves are given (reproduced in Fig. 1, herewith), showing the floor space required for horizontal steam-engines (Curve I.), vertical steam-engines (Curve II.), and the Parsons steam-turbine (Curve III.). The writer has added on the same diagram the curves for the Curtis steam-turbine (Curve IV.) and the average gas-engine (Curve V.). Mr. Sniffen assumed for his conditions 7 ft. of clear space all around for the following plants: Two 400-KW. units; three 750-KW. units; four 1,000-KW. units; three 2,500-KW. units; four 2,500-KW. units; four 5,000-KW. units; seven 5,000-KW. units; and ten 5,000-KW. units. This classification will answer our present purposes. The diagram shows the Curtis turbine

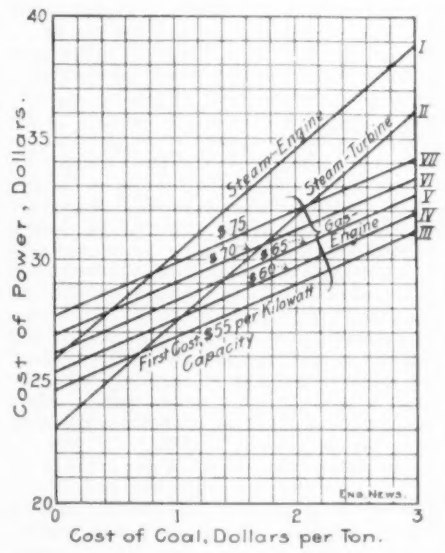

Fig. 6. Curves of Power-Cost for Steam Engines, Steam Turbines, and Gas Engines, for Various Prices of Coal.

to some advantage, for if volumetric engine-room capacity were considered the two types of turbine would require about the same space, owing to the greater height of the Curtis type. The Curtis type has an advantage in this respect, however, since its height is not excessive and adds nothing to the cost of the building.

But this diagram does not tell the whole story. The boiler capacity is the same for engines and turbines and if an engineer designs his engine room before his boiler-room, and on an economical basis, he may be somewhat surprised. In the sketch diagrams, Figs. 2 to 4, is shown a plant of three 1,500-KW. vertical turbines, with the required boiler capacity, laid out in three different ways. Fig. 2 shows the ordinary back-to-back arrangement which evidently lacks economy. In Fig. 3, the boilers are thrown into two sections on the same level, while Fig. 4 shows a double-decked arrangement. Fig. 5 shows that conditions are not materially different for the horizontal turbine. The extra space not needed by the engines in these lay-outs, especially Fig. 2, could be used for other purposes, if such a long narrow lot were under discussion. When we remember the cost of installation and repairs, and the added risk of such an excessive length of high-pressure piping, and also that about .07 lb. of steam is condensed per square foot of covered steam pipe, we shall not have much liking for that lay-out. In most cases there would be an added expense on the coal-handling account.

Engineers have seldom designed double-decked boiler houses except when forced to it by circumstances. In engine installations these cases have been very few owing to the large amount of space required by the engines. Just why the double-decked arrangement should be objectionable is hard to state. The damage risk owing to the explosion of a lower boiler is almost nothing with the water-tube type, while the piping is exceedingly direct and economical. The chief difficulty would seem to be in the coal and ash handling, which is certainly not a great one. Figs. 4 and 5 show how compactly a plant might be designed on these lines, and the writer believes that in many cases this type will of necessity be adopted in steam-turbine stations.

This calls to mind some of the arguments that have been heard lately in regard to replacing engines by turbines in old engine rooms and so getting more power in the same floor space. This is impossible unless we can expand our boiler room somehow. This may also demand the double-decked arrangement, owing to the impossibility of expansion in other directions. The double-fired boiler which is being experimented with by some just at present may alter these conditions somewhat, but probably not much.

In any case the turbine shows a great saving in engine-room space, and room used for other purposes as suggested in Fig. 2, certainly cannot be charged to power. No value can be put down for cost of engine room that will suit all cases.

The gas-engine will require a little less space than the steam-engine, but a more expensive foundation, so the costs are assumed almost the same in Table I. A comparison of the space required for boilers and for producers shows some interesting facts. The amount of space assumed for boilers is an average of that required by several makes of the water tube type, though the most efficient make of this type known to the writer requires only 1.28 sq. ft. total floor space, and occupies only 26 cu. ft. per boiler HP., which is very compact indeed.

In Table II. is given a summary of floor space required by producer plants of various capacities. This table was arranged for the writer by R. D. Wood & Co., of Philadelphia, Pa., and gives approximate values only for Taylor and Mond producers. This shows an average value of 1.7 sq. ft. per engine HP., which is about the same as required by the boilers.

TABLE II.—Approximate Dimensions of Space Required for Producer and Holder, for Taylor and Mond Gas-Producer Plants.

Capacity.	Length. Taylor.	Length. Mond.	Width. Taylor-Mond.	Height. Taylor.	Height. Mond.
500 HP.	42 ft.	68 ft.	26 ft.	20 ft.	30 ft.
750 HP.	45 ft.	70 ft.	28 ft.	25 ft.	35 ft.
1,000 HP.	45 ft.	70 ft.	40 ft.	25 ft.	35 ft.
2,500 HP.	50 ft.	80 ft.	80 ft.	25 ft.	35 ft.
5,000 HP.	50 ft.	90 ft.	155 ft.	25 ft.	40 ft.

AUXILIARIES AND PIPING.—There is no difference here between the steam-engine and the steam-turbine, remembering that the piping between the throttle and exhaust connection is included in the cost of the engine. The quotations for gas-engines which the writer has been able to obtain do not permit of easy separation of costs, so a total is given. The external piping amounts to very little, and the auxiliaries to nothing outside of a tank for starting and a pump.

ENGINE AND GENERATOR.—Little can be said here, since the values given are direct quotations. The steam-turbine should gain a little in the generator cost owing to its increased speed, and the general reduction of weight, but one well-known firm quotes its turbine units at the same price approximately as its reciprocating units. For years generator design has been governed by the demands of the Corliss engine. The writer was concerned in the installation of two Corliss engines during the past year where the speed was 110 r. p. m., which is very close to the limit. Engines are running as high as 150 r. p. m., but most engineers would hesitate about going beyond 120 r. p. m. On the other hand turbo-generators run at speeds varying from 1,000 to 4,000 r. p. m., according to size and frequency.

The cost of gas-engines is certainly excessive. The writer has had quotations for large engines varying from $55.00 to $40.00 per HP., f. o. b. works. These prices will come down, or the intro-

duction of gas-engines will be greatly retarded. This is the most serious handicap the gas-engine has at present, in fact the only real one. The loss here cuts down a large part of its gain in economy. The best steam engines of this size can be bought for about 7½ cents per pound, gross weight, and it seems unreasonable that a gas engine should cost much more. The gas engine gains, of course, in the absence of auxiliaries.

BOILERS AND PRODUCERS.—In the boiler-room estimates we have included all that modern practice demands except coal storage and power handling of coal. How much coal storage is necessary, and how the coal will be stored, depends largely on local conditions. Engineers are storing coal in open yards, under covered sheds, under water in a few places, and in steel bunkers either suspended like the Berquist type or of the old structural type. Power handling of coal will be found economical except in a small number of cases where the coal can be dumped close to and higher than the fire doors. Since the capacity of the storage and conveying plant for the gas plant need be only half that for the steam plant, there will be a saving here in favor of the former.

The figure quoted for the producer includes a conveyor to the top of the producers, a shed over the producers, and all auxiliaries necessary for delivery of gas to the engines. The figures apply to the simple Taylor producer; whether the Mond or other by-product producer will ever become popular among power engineers is a question that only time can answer. It depends upon how much the extra complexity is objectionable, and upon the demand for the by-product.

OPERATION AND FIXED CHARGES.—We have lumped fixed charges at 15%; this means interest at 5%, taxes at 2% and depreciation at 8%. Depreciation on different parts of the plant will vary from 5 to 15%, but 8% will be found to come very close to more detailed calculation. Depreciation on well-built gas engines will not be very different from that on the same quality steam engines. Depreciation on the foundations should be taken in every case at the same rate as on the engines, since they are useless when the engines are taken out and must be removed.

The gas plant gains in the labor item on account of the smaller amount of coal to be handled, both as coal and as ashes, smaller cleaning and repair force, and the absence of auxiliaries in the engine room. As stated elsewhere our conditions are coal at 0.1 cent per pound, a year of 365 days of 20 hours each, and a 50% load-factor. This means that the total yearly watt-meter reading is one-half the rated yearly kilowatt-hours of the station. Under this definition the usual electric railway load-factor is about 50%. The load factor will influence calculations on oil and coal costs.

We have assumed the coal consumption to be the same for steam engines and steam turbines, i. e., 4 lbs. per KW.-hr., and 2 lbs. per KW.-hr. for the gas engine. This is as close as one is warranted in estimating in a case of this kind. The best water rate the writer has seen recorded for a two-cylinder condensing engine with superheat is 10.17 lbs. per I. HP., which is about 17 pounds per KW.-hr. This is very low, for 19 lbs. per KW.-hr. is considered unusual and 25 lbs. is probably average. So far the steam turbine has not done better, though whatever economy it has at the start it is likely to keep until it breaks down, since experience shows that there is nothing to wear except the bearing. It should be noted that the high values given above depend upon high vacuum, superheat, and very close attention. Theoretically, and in contract trials, 27 ins. of mercury is a very ordinary vacuum, but in a large number of stations that the writer has visited in the last few months the vacuum was seldom over 23 ins. We must have considerable education along this line if we are to realize the greatest economy, particularly with the turbine, since its efficiency seems to suffer more from poor vacuum than does that of a steam engine.

GENERAL CONSIDERATIONS.

If what we have said be true the "three-cornered fight" of which the technical journals have been talking ought to be already over, but this is far from being so. In the above estimates, using what are meant to be conservative figures, there is a yearly saving, per installed kilowatt, of $2.85 by the steam turbine and $4.90 by the gas engine over the steam engine. These seem like very great differences, but they may become even greater with increased experience.

The writer believes that from now on the decision will usually lie between the steam turbine and the gas engine for all units. The simplicity of the steam turbine is really the source of its many advantages. One has only to stop and think of the hundred adjustments, places to wear, etc., of the reciprocating engine to realize this. We have become so accustomed to them that they seem very simple, but they are not. Watch the engineers and oilers on a Manhattan type, or even a less ponderous engine, and then see the one man on a steam turbine with nothing to examine but a bearing or two, and these accessible without a climb of thirty feet in the air or a walk of two hundred feet on the floor.

We formerly heard much about the greater economy in the use of steam by means of the steam turbine, but later experiments have shown these statements to be unwarranted. Owing to the absence of valves and of lubrication on the steam surfaces, the use of superheat is very easy. In Europe the difficulties of superheat in connection with reciprocating engines seem to have been entirely eliminated. With us, superheat has been almost a bugbear, and just the reason for this is hard to state. True, it will always be more troublesome than saturated steam, even with the steam turbine, for we shall still have our long lines of piping; nevertheless the steam turbine renders its use much easier.

We have already referred to the necessity for very high vacuum in steam-turbine work, and this fact should be kept in mind. Regulation can be made almost perfect owing to the absence of reciprocating motion and the continuous supply of energy. Since there is no oil in the exhaust the water may be used over and over, a very important point where water is costly. When conditions demand it, the time for manufacture and erection can be made exceedingly small. In short there is every reason why an engineer can afford to install a steam turbine rather than a steam engine, even if it did not mean such a large direct saving in cost of power.

But our figures also show the gas plant to be best of all. The question might therefore be put as to why the others are not immediately and completely discarded. There are many reasons, of course, but the chief ones are very apparent. First, the field is new and men must be absolutely sure, not reasonably so, that the wheels will turn; second, many of the manufacturers of gas-engines are also interested in steam engines and steam turbines, and consequently the energy applied to the introduction is divided; and third, the first cost of the gas engine is excessive. Whether the gas engine is more economical than the steam turbine depends on the relative prices of the engines and the price of coal.

In the calculations summarized in Table I., a single value was taken for the cost of the engine and a single value for the coal. To show how changes in these amounts would affect our results, the curves in Fig. 7 are presented. Here abscissas represent cost of coal in dollars per ton and ordinates represent cost of power in dollars per kilowatt-year under the previous conditions. Curve I. is for the steam engine, Curve II. is for the steam turbine, and Curves III., IV., V., VI. and VII. for the gas engine when the engine alone costs $55, $60, $65, $70, $75, respectively, per kilowatt of capacity. The points at which the gas engine curves cross the steam turbine curve show the minimum prices of coal for which the gas engine is as economical as the turbine. At present prices of engines coal must cost at least $2.15 per ton to justify installing gas engines on the score of economy.

This excessive price of gas engines also acts in an indirect way to retard its introduction, on account of the well-known objection of financial men to high first cost. It is hard enough just now to convince the skeptical, without having this added handicap.

In Europe no engineer would hesitate to install gas engines unless he could obtain power more cheaply by some other means. It is regarded there as entirely reliable, but is placed only in the hands of men who have had a thorough training in its requirements and possibilities. It is theoretically and practically much more efficient than any steam prime mover, the plant is remarkable for its simplicity and consequently the liability to shut-down is greatly reduced. The plant has great possibilities of power storage at little cost. The producer is probably 10% more efficient than the steam boiler, and even more so if the condensation losses in pipes, traps, etc., be included. Indeed, a poorer quality of coal might be used in the producer for results equal to those of the boiler.

It seems almost a law that an inferior type must be developed to its highest efficiency, while a superior one waits its turn. We shall therefore wait a little while for the general introduction of the gas engine; but only a little while, since fortunately the steam turbine is going ahead with rapid strides and would seem to have little farther to go. There are companies to-day handling all three types that could afford to drop their steam apparatus and come out boldly as champions of the gas plant. Soon perhaps we shall realize the ideal of a single large power-station for each community—a large station in the outskirts of the city, near a body of water, with no smoke stacks, consisting of a gas-engine plant running on producer gas with a by-product factory in the rear, leaving nothing to be hauled from the plant but a useful finished product. Meanwhile the world will have about three times as long to search for the substitute for coal.

THE PHILADELPHIA RAPID TRANSIT RAILWAY.

GENERAL DESCRIPTION.

Work has been in progress for some months on a rapid transit railway system for the city of Philadelphia, Pa. This railway will be partly underground and partly elevated structure, and its mileage, while it is not definitely determined at present, will place the completed system well up in the list of the great urban rapid transit railways of the world.

DEVELOPMENT OF THE PROJECT.—Compared with other American cities of the first magnitude Philadelphia has been distinctly backward in developing facilities for rapid transit between distant sections. In fact it can with substantial truth be charged with being without means of rapid transit. Its surface railway system has, like that of other large cities, grown rapidly and has partaken of all the improvements in motive power and rolling stock which have signalized street railway transportation since 1890, but the surface street railway, whatever its motive power may be, is not and cannot be a rapid transit railway in the present-day sense of that term, and the city of Philadelphia has had no other city passenger railway. There has been no failure in recognizing this want, however. As many as 15 years ago a project was launched for an elevated rapid transit railway system in Philadelphia. It was succeeded by several other projects, all for roads of the same character, that is elevated railways operated by steam locomotives after the pattern of the elevated lines of New York City. These projects all came to naught for various reasons, but the principal reason was the illegality of such constructions.

The laws of the State of Pennsylvania did not until within a few years permit the construction and operation of elevated passenger railways. This at least was the interpretation of the courts before which the question came. In view of this condition and through the efforts of interested parties a law was passed permitting the construction of elevated passenger railways in Pennsylvania cities of the first and second classes. The passage of this law was the signal for the seekers of franchises and in a short time such privileges had been secured for a number of lines within the city of Philadelphia. These were gradually secured one after another by the interests which are now officially known as the Philadelphia Rapid Transit Co.

To enter somewhat into detail, the so-called

Focht-Emery transit bills were passed in the spring of 1901, and on June 13, 1901, Mayor Ashbridge signed franchises for the Ridge Ave. elevated; the Frankford elevated; the Passyunk Ave. elevated; the Germantown Ave. elevated; the Broad St. subway, and the Market St. elevated. A franchise for the Market St. subway from the Delaware River to the county line was secured on April 9, 1902. As stated, all these franchises were taken over by the Philadelphia Rapid Transit Co.

As soon as these franchise transactions were completed efforts were turned toward giving the various authorized lines a practical existence. This involved a large amount of work. The scope and character of the system were first to be determined, then the plans for structures and construction had to be devised. It was fully a year after beginning work that these tasks were in a sufficient stage of advancement to permit contracts to be let. This was done for the first section of the line on March 16, 1903.

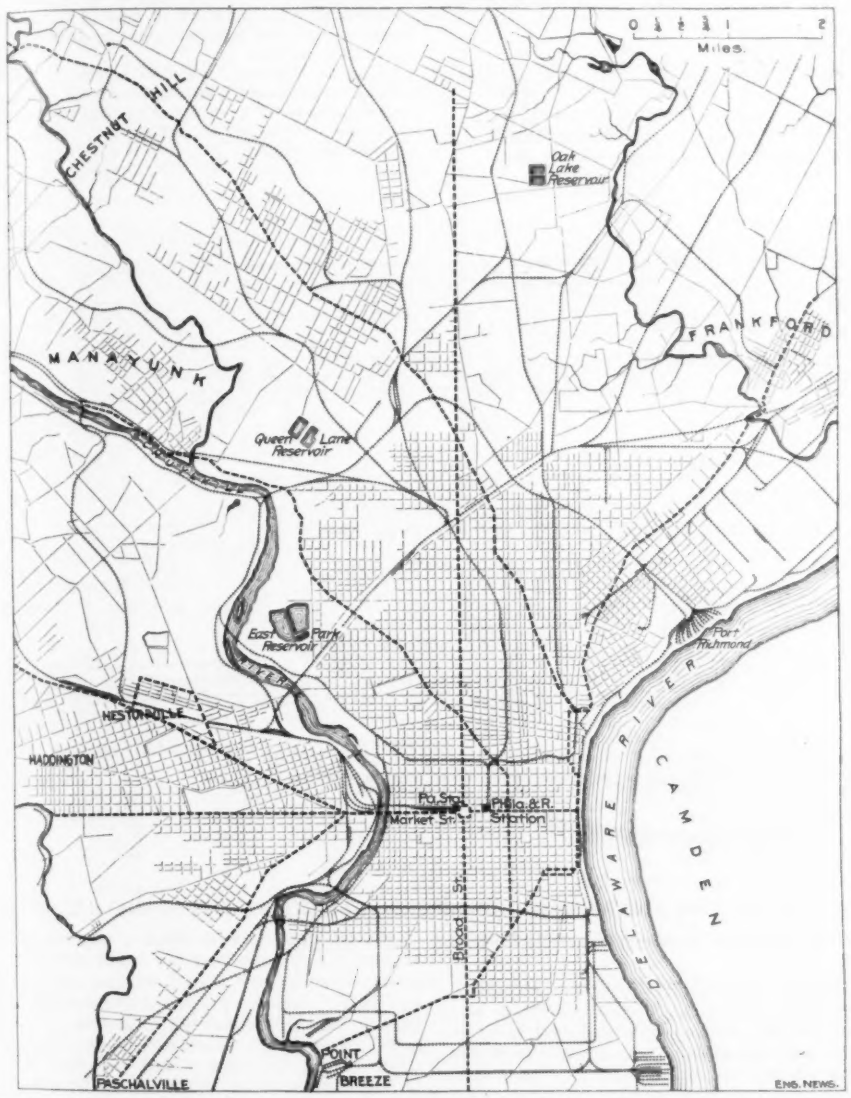

FIG. 1. MAP SHOWING PROPOSED ELEVATED AND SUBWAY LINES OF THE PHILADELPHIA RAPID TRANSIT RAILWAY.

GENERAL PLAN OF SYSTEM.—The general plan of the Philadelphia rapid transit system is shown by Fig. 1, in which the elevated lines are shown full and the subway lines broken. As will be seen, there is an underground line the full length of Broad St., and on Market St. an underground line for the greater part of the distance between the Delaware River on the east and the Schuylkill River on the west. All the other lines are elevated and their routes and termini are clearly indicated by the map. The two underground lines, one running substantially north and south and the other running east and west, intersect in a loop, which passes entirely around the City Hall. The general layout of the line is, therefore, substantially radial in plan, which is the plan best designed to meet the traffic conditions of the city.

Philadelphia, like New York, is located chiefly on a peninsula of land, bounded by rivers on the east, west and south. Unlike New York, in which the preponderance of travel is north and south the traffic of Philadelphia is radial from a congested center located not far from the center of population of the city. Any preponderance of travel that may exist is in the east and west direction. The congested section of the city is an area about half a mile wide and about a mile long, with Market St. as the longitudinal axis and the Delaware River and 15th St. as the east and west boundaries. In this area are located the two great steam railway passenger terminals of the city, the hotels, theatres, public buildings, office buildings and financial and commercial houses. To relieve this congested area was the first purpose of the Philadelphia Rapid Transit Co., and to carry this purpose out it was decided to build the Market St. line of its system first, and, furthermore, to make use of its subway franchise for this street for at least the bulk of the distance between the two rivers.

THE MARKET ST. LINE.

The Market St. line of the Philadelphia Rapid Transit Railway extends from 63d St. along Market St. to the east bank of the Schuylkill River as an elevated structure, and then underground along Market St. to Delaware Ave., where it emerges from beneath the surface and rises to an elevated structure, which runs south along Delaware Ave. to South St. Beginning at the City Hall and working both ways, the general line structure is planned to be as follows:

Around the City Hall there is to be a double-track loop. From this loop a four-track subway will run west to 23d St. The tracks of this subway will be on the same level. At 23d St. all four tracks emerge from beneath the surface at the same level and ascend an incline reaching to the east end of the center span of a bridge across the Schuylkill. At this point the grades of the outside and the inside tracks separate. The outside tracks continue across the bridge on the level and descend an incline to the street surface; the two inside tracks, however, continue on a rising grade across the bridge, and at its west end enter upon the elevated structure which extends west along Market St. to 63d St. The Schuylkill bridge and inclines are shown by Fig. 2.

The foregoing paragraph accounts for the Market St. line west from the City Hall loop. East from this loop the line will be a double-track subway to Delaware Ave., where it will rise onto the elevated structure along Delaware Ave. The detail plans for this portion of the line are not yet ready to be made public, but work is in progress on a portion of the line from the City Hall loop west. Specified exactly, the portion of the line which is now formally under construction is the four-track subway from 15th St. to the Schuylkill River, including the 19th St. station. For this section the plans and specifications have been completed and are given in their essential features in the following paragraphs.

ASSUMED LOADINGS ON SUBWAY STRUCTURE.—Preparatory to designing the subway structure a careful study was made of the loads to be assumed in calculating its strength. These assumed loads have been given to us by the Chief Engineer and are in his words as follows:

VERTICAL LOADING ON ROOF.

DEAD LOAD.—Allowance is made for the heaviest pavement liable to be placed, viz.: granite blocks on 6-in. concrete base. The weight of this pavement, allowing for depth of 15 ins., which includes a 3-in. sand cushion under blocks, is 175 lbs. per sq. ft. The weight of the earth is taken at 110 lbs. per cu. ft., below the base of the pavement. The total dead weight resting on the top of the roof thus varies between 260 lbs. per sq. ft. for a 2-ft. cover, up to 1,140 lbs. for a 10-ft. cover, and proportionately for other depths. The minimum cover above the top of the roof is 4 ft., except in special cases, and the maximum, as far as the work has progressed up to this time, is between 9 and 10 ft.

LIVE LOAD.—The roof, including concrete steel slabs, metal girders at the stations, sidewalls, columns, etc., are proportioned by the following live loads:

Concentrated Loads.—The concentrated load consists of 10 tons on each of four wheels, making 40 tons in all, 20 ft. between axles, and gage, 6 ft. This load is considered distributed by the pavement and the earth, between the pavement and the roof. In this distribution, equivalent loads for simplicity of computation are worked out so that each of the two pairs of wheels is replaced by a rectangle loaded with a load equivalent to the weight on the wheels. These rectangles are the same distance c. to c. as the axles, viz.: 20 ft. The equivalent distributed load on the said rectangles varies from 1,180 lbs. per sq. ft. for a 4-ft. cover to 200 lbs. per sq. ft. for a 16-ft. cover. The loads for intermediate covers varying, though not directly, with the depth. Where the cover is 3 ft., the load is 1,330 lbs. per sq. ft. Special shallow construction is treated as each individual condition makes necessary.

General Load.—In addition to the foregoing concentrated loads, a general load of 200 lbs. per sq. ft. is applied exterior to a space 30 ft. long and 11 ft. wide, placed symmetrically to the concentrated load, the greater length parallel with the longitudinal axis of the latter.

The foregoing loads are applied so as to produce the maximum effect on any member of the construction. The concentrated load used in this work is in accordance with experience in Philadelphia covering a number of years, and is considered an adequate allowance for the heaviest loads liable to be transported about the streets.

LATERAL LOADING ON SIDEWALKS OF SUBWAY.

The lateral pressure on the sidewalks allowed for, consists of two parts: (1) The dead weight of the material exterior to the walls, and, (2) Superficial load of 200 lbs. per sq. ft. The pressure on the walls is computed by the theory of earth pressure as developed by Rankin. The coefficient by which the pressure is determined, varies in the different soils, and is based on experience in dealing with the soils in Philadelphia. In special cases where the work approaches closely to heavy buildings, the weight of the latter are considered in determining the strength of the walls, as there is no rock above the floor of the subway, except in very few places. Where continuous masonry structures, such as manholes, or other street appurtenances are founded upon the roof of the subway, by which the estimated distribution of the concentrated loads would be partly vitiated, grillages will be placed to insure proper distribution to correspond with the allowed loads.

MATERIALS PENETRATED.—The bulk of the subway excavation will, according to the records of the borings, be through gravel and sand. Along the eastern portion of the line there is an overlying bed of clay and toward the western end subgrade of the excavation will penetrate two or three feet into underlying mica rock. The ground water level rises above subgrade about midway between 19th and 20th Sts. and is some 6 ft. above the floor level at 22d St. The subsoil is on the whole of a stable character and will, it is expected, stand up well under excavation.

STREET AND ADJACENT STRUCTURES.—The bulk of the subsurface street structures along Market St. lie above the roof line of the subway. These consist of sewers, water and gas pipes and electric wire conduits for various services. The large sewers of the cross-streets generally lie below the roof of the subway, but the various other conduits with few isolated exceptions clear the top of the subway structure. During construction the contractor will be required at his own cost to support all these structures which he may uncover, but where the structure encroaches upon the subway space and has to be raised or otherwise relocated, this work will be done at the cost of the owner. This is true of city property as well as private property, with the exception of sewers. Above surface structures, such as poles, signal boxes, wires, etc., are to be maintained in position in working order by the contractor during constructions, but any alterations required in these structures are to be made by their respective owners. The bulk of the buildings which border Market St. along the line of the work under way are brick structures from two to five stories in height; but toward the west end of the work there are a number of high and heavy structures. The most notable of these are the 9-story bank and the 14-story Arcade Building, on the southeast and southwest corners of 15th St. The contractor is required to preserve all bordering buildings from damage, underpinning them or performing whatever other work is necessary for their safety at his own expense. As a rule the sidewalls of the subway will come close to the curb lines of Market St. throughout the section.

SUBWAY STRUCTURE.—The standard subway is a four-track structure with all the tracks at the same level. To illustrate the subway structure in detail plans of the standard four-track section will be selected, and these are shown by Fig. 3. In general it will be noted that the structure is rectangular with three lines of steel columns supporting the roof.

The subway floor is composed of a layer of 1-3-6 concrete. The sidewalls are of composite construction. There is first an inside wall of reinforced 1:2½:5 concrete, then a tier of vitrified clay wire ducts, and finally an outside wall of 1:3:6 cinder or slag concrete with a water-proof coating on its inside. Each pair of columns longitudinally is further encased in a bulkhead. These constructions are clearly shown by the drawings of Fig. 3. These drawings also show clearly the character and arrangement of the steel reinforcement. All the transverse reinforcing rods in the sidewalls are Thacher patent rods and all longitudinal rods are plain rounds. It will be observed that all the steelwork is completely embedded in concrete.

WATERPROOFING.—The subway structure, including the stations, stairways, manholes and every part of all exterior walls and roof is to be thoroughly waterproofed. The specifications for this waterproofing are as follows:

MASTIC.—The composition of the waterproofing on the floor and on the roof denominated as "mastic" in these specifications shall be as follows: The asphaltic rock forming the basis of the mastic shall be Seyssel, Limmer, Sicilian or Neuchatel, of the best quality and imported in the crude state. Such rock shall be prepared and manufactured with asphalt as a flux, to be composed of Bermudez or Alcatraz asphalt or a mixture of them, made into blocks, properly marked and branded. These blocks shall be broken up and melted on or in the immediate vicinity of the work and prepared for use by the admixture of materials, as stated in the following: The mixture shall consist of 70 parts by weight of the aforesaid asphaltic mastic as received in cakes or blocks, ten parts by weight of refined Bermudez or Alcatraz asphalt or a mixture of them, and 20 parts by weight of sharp grit and sand that will pass a sieve of 8 meshes to the lineal inch, free from dust and dirt. As the mastic is melted, the grit and the asphalt, having been previously heated to the same temperature as the mastic, shall be added, and the whole mass heated to a temperature of 260 to 280° F. and thoroughly mixed. After a sufficient time of boiling, the mastic is to be carried to the work in wooden pails or barrels and there carefully spread over the floor and roof with wooden spatulas to such a depth that it, after having received its ultimate compression it will have a thickness of not less than ½-in. The mastic so applied shall be thoroughly worked until it is entirely free from voids and thoroughly compacted. Care shall be exercised so that the grit used shall be free from particles exceeding the size herein specified, and the surfaces well brushed and free from pebbles or any particles which will roll about in smoothing and compacting the mastic and thereby produce defective spots in the covering.

All surfaces upon or against which waterproofing is to be placed must be dry and approved before waterproofing is applied. In particular situations apparatus for local application of heat shall be used if necessary to expedite drying of the surfaces. In the floor where necessary, sumps with drainage channels shall be provided so that water may be removed by pumping in advance of the waterproofing. In all cases every available method or piece of apparatus shall be used as may promote securing dryness on all surfaces to which waterproofing is to be applied. In particular situations where special difficulty is encountered in securing dryness on surfaces to be waterproofed, the method to be pursued shall be in accordance with most approved usage as applicable to the materials prescribed.

Should felt undipped in asphalt be used in special situations, to overcome difficulty in placing waterproofing materials, such will be estimated as additional waterproofing at the price for felt and asphalt waterproofing as provided in the proposal.

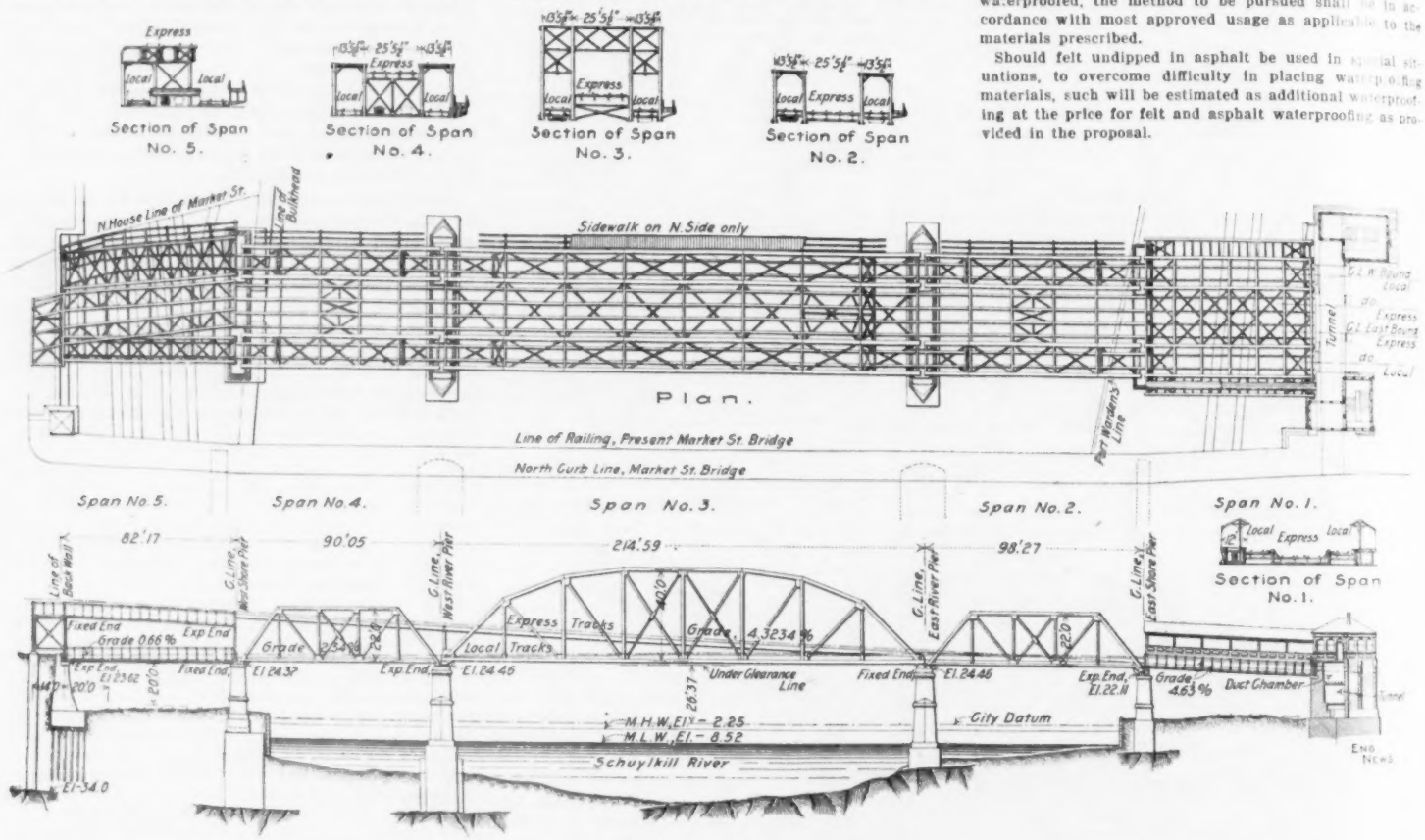

FIG. 2. PLANS AND SECTIONS OF BRIDGE AND INCLINES CONNECTING ELEVATED AND UNDERGROUND LINES AT THE SCHUYLKILL RIVER.

DUCTS.—To carry the electric conductors a tier of conduits is built into the south sidewall. The conduits are of salt glazed vitrified clay in 18 in. and 24 in. lengths. The nominal diameter of each duct is 4 ins. The manner of laying the conduits is stipulated by the specifications as follows:

Before laying, the inside of each duct shall be scraped by means of a spring scraper which shall be pushed through each duct. The ducts shall be laid in cement mortar about ¼-in. in thickness, with broken joints and with full bearing. Two strips of thick muslin, 6 ins. wide and saturated with neat cement mortar shall be used to wrap each joint, the ends of the wrap to lap at least 4 ins. In laying the ducts care must be taken to close abutting joints so that the ends of the ducts shall practically be in contact on all sides. Where ducts are laid on curves, the wraps must be doubled, if so ordered by the Chief Engineer, to protect the openings on the outer side of the curves. The purpose of the muslin wrapping is to exclude water and other material from entering the ducts at the joints, and the utmost care shall be taken to positively exclude the entry of mortar, dirt, or any material whatever. A mandrel shall be drawn through each duct as it is laid. The mandrel is to be of a diameter ¼-in. less than the internal diameter of the duct. The length of the mandrel shall be 36 ins. The mandrel shall be left in each duct until the next succeeding duct is laid. After the ducts are laid, their centers must be in perfect horizontal and vertical alinement. After the ducts have been in place for a sufficient time for the mortar to partially set, they shall be wired and a steel cleaner, 12 ins. long and ¼-in. less in diameter than the inside diameter

of the duct, pulled through. If obstructions are found which cannot be removed by this method, the ducts so obstructed shall be taken out and relaid.

Access to the ducts is obtained by manholes spaced every two or three hundred feet. These manholes are to be constructed of brick, and provided with cast-iron covers.

19TH ST. STATION.—The only station on the portion of the Market St. line that is under construction is located at 19th St., and it provides connection with only the two outside tracks, these being deemed sufficient to accommodate all the traffic. Like the subway proper, it is built largely of reinforced concrete.

MATERIALS.—The principal materials employed in construction of the subway are cement, mortar, concrete and steel, and these are quite clearly described by the following extracts from the specifications:

CEMENT.—Portland cement shall be used in all mortar, concrete and grouting required by these specifications, and wherever the word "cement" is used it shall be understood as meaning Portland cement.

The cement shall leave a residue by weight of not more than 10% on the No. 100 sieve, and not more than 30% on the No. 200 sieve. The cement shall have a specific gravity of not less than 3.10. Cement mixed neat to form a paste of normal consistency, the surrounding temperature as near to 70° F. as practicable, shall not develop initial set in less than 20 mins., and must have acquired its hard set in less than 10 hrs. The cement is considered to have acquired its initial set when a needle 1 mm. in diameter loaded to weigh 300 grammes ceases to penetrate within 5 mm. of the bottom of a cake 40 mm. deep, and to have acquired its hard set when the same needle ceases to make a visible indentation on the surface of the cake.

The cement shall pass the following test for soundness: For these tests, pats about 3 ins. in diameter, ½-in. thick at the center, and tapering to a thin edge, should be made, upon a clean glass plate from cement paste of normal consistency. These pats shall be allowed to remain 24 hrs. in moist air before immersion in water or steam. A pat is immersed in water maintained as near 70° F. as possible for 28 days, and observed at intervals; the pat shall remain firm and hard, and show no signs of cracking, distortion or disintegration. A pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel, for 3 hrs. To pass this test satisfactorily, the pats shall remain firm and hard, and show no signs of cracking, distortion or disintegration.

Cements failing to meet the requirements of the accelerated test will not necessarily be rejected, but shall be held until the results of the normal tests are ascertained.

Tensile tests shall be made on specimens prepared and maintained until tested at a temperature as near as practicable to 70° F. Each specimen shall have an area of 1 sq. in. at the breaking section, and after being allowed to harden in moist air for 24 hrs. shall be immersed and maintained in water until tested, except for the specimens for the 24-hour tests, which shall be immersed in water after hard set. The sand used in preparing test specimens shall be clean, sharp, crushed quartz retained on a sieve of 30 meshes per lineal inch, and passing through a sieve of 20 meshes per lineal inch. The tensile strength from test specimens shall be as follows:

Neat Cement.	
24 hrs. (in water after hard set)	150 lbs.
7 days (1 day in air, 6 days in water)	500 "
28 days (1 day in air, 27 days in water)	600 "
1 part Cement, 3 Parts Sand.	
7 days (1 day in air, 6 days in water)	170 lbs.
28 days (1 day in air, 27 days in water)	240 "

The cement shall not contain more than 1.75% of anhydrous sulphuric acid.

The rules recommended by the Committee of the American Society of Civil Engineers, on uniform tests of cement, as published in "Proceedings" of the said society for the month of January, 1903, will be followed in making the above tests.

MORTAR AND GROUTING.—All mortar to be used in the building of masonry shall be composed of 1 part of Portland cement to 3 parts of sand. Mortar for pointing, and bedding any bearing stones or copings shall be composed of 1 part Portland cement to 2 parts of sand.

Grout shall be composed of 100 lbs. of Portland cement to 3 cu. ft. of sand, except when the foundations are wet, when the quantity of sand shall be diminished, making the proportions 100 lbs. of cement to 2 cu. ft. of sand, which shall be used in foundation masonry, up to the neat lines, if required. All of the above mixtures shall be proportioned by measurement, not by estimating, and shall be first thoroughly mixed dry in suitable tight boxes, after which the proper amount of water shall be gradually added. Only such quantities of mortar or grouting shall be mixed as are needed for immediate use; if allowed to set, it shall not be retempered and used in any masonry construction. Sand for grouting shall be tide-washed, sharp, silicious, dry-screened bar or approved flint bank sand, free from all loam, dirt or dust. Sand for mortar shall be composed of grains graded from coarse to fine, thoroughly screened to reject all particles exceeding ⅛-in. in diameter, and shall be clean and sharp, free from loam, dirt or dust, and equal in quality to the best New Jersey bank sand. The water shall be fresh and free from dirt. Permits must be obtained from the Bureau of Water to use fire hydrants. Salt water may be used when directed by the Chief Engineer, when necessary to construct masonry in cold weather. Mortar in the proportion of 100 lbs. of cement to 3 cu. ft. of sand, taken from the mixing box, and molded into briquettes 1 sq. in. in cross-section, shall develop the following ultimate tensile strengths: 7 days (1 day in air, 6 days in water), 125 lbs.; 28 days (1 day in air, 27 days in water), 175 lbs.

CONCRETE.—Concrete shall be composed of Portland cement, gravel or coarse sand and crushed stone.

The gravel or coarse sand shall consist of grains graded from coarse to fine, screened to reject all particles exceeding ¼-in. in diameter, free from loam, dirt, or dust, and equal in quality to the best New Jersey bank sand or gravel.

The crushed stone shall be of granite, trap rock, or other hard quarried stone, to be approved by the Chief Engineer. It shall consist of the run of the crusher, properly screened and cleansed to remove all dust and dirt, the largest pieces not to exceed 1 in. in any direction. It is to be understood that the stone shall be the run of the crusher, screened and cleansed as aforesaid so that it shall be graded in size, so as to consist of a mixture of sizes, ranging from the largest size specified down to the clean grit. Stone shall be wetted in advance of its distribution or delivery to the mixers, when and as directed by the Chief Engineer. In concrete for foundations, where the thickness is 30 ins. or more, the contractor may imbed broken pieces of approved hard stone whose greatest diameter shall not exceed 12 ins., and whose least diameter or thickness is not less than two-thirds the greatest diameter. These stones shall be well wetted and set by hand in the concrete as the layers are being rammed, shall be well settled with rammers in the fresh concrete, and so placed that each stone is completely and perfectly bedded. No two stones shall be within 8 ins. of each other horizontally, so that the concrete may be properly rammed between them, and there shall be not less than 6 ins. of concrete vertically between any stones. No stones shall approach nearer than 4 ins. of any exposed face, or any face which shall be finished to receive subsequent placing of other materials, or other construction.

The proportions of cement, gravel or coarse sand and crushed stone in making concrete shall be as follows: Mixture A—100 lbs. cement, 2½ cu. ft. gravel or coarse sand, and 5 cu. ft. crushed stone; Mixture B—100 lbs. cement, 3 cu. ft. gravel or coarse sand, and 6 cu. ft. crushed stone.

Cinder concrete shall be composed of 100 lbs. cement, 2 cu. ft. gravel or coarse sand, and 6 cu. ft. of cinders. The cinders shall be from hard coal, clean, free from ashes, and all large pieces broken so that none shall be larger than 1 in. in any direction. Slag concrete shall be composed of 100 lbs. cement, 2 cu. ft. gravel or coarse sand, and 6 cu. ft. slag. The slag shall be clean furnace slag, crushed so that no pieces will be larger than 1 in. in any direction.

All concrete shall be mixed in a mechanical mixer of style to be approved by the Chief Engineer, except where limited quantities are required under any particular circumstances, where hand-mixing may be allowed if approved by the Chief Engineer. Machine mixing shall be so conducted that successive definite charges shall be mixed as the progress of the work demands, and continuous mixing avoided. Where hand-mixing is done under the aforesaid limitations, the cement and gravel or coarse sand shall be first mixed dry and then made into a mortar, as required in the paragraph entitled "Mortar." The crushed stone shall be spread out to a depth not to ex-

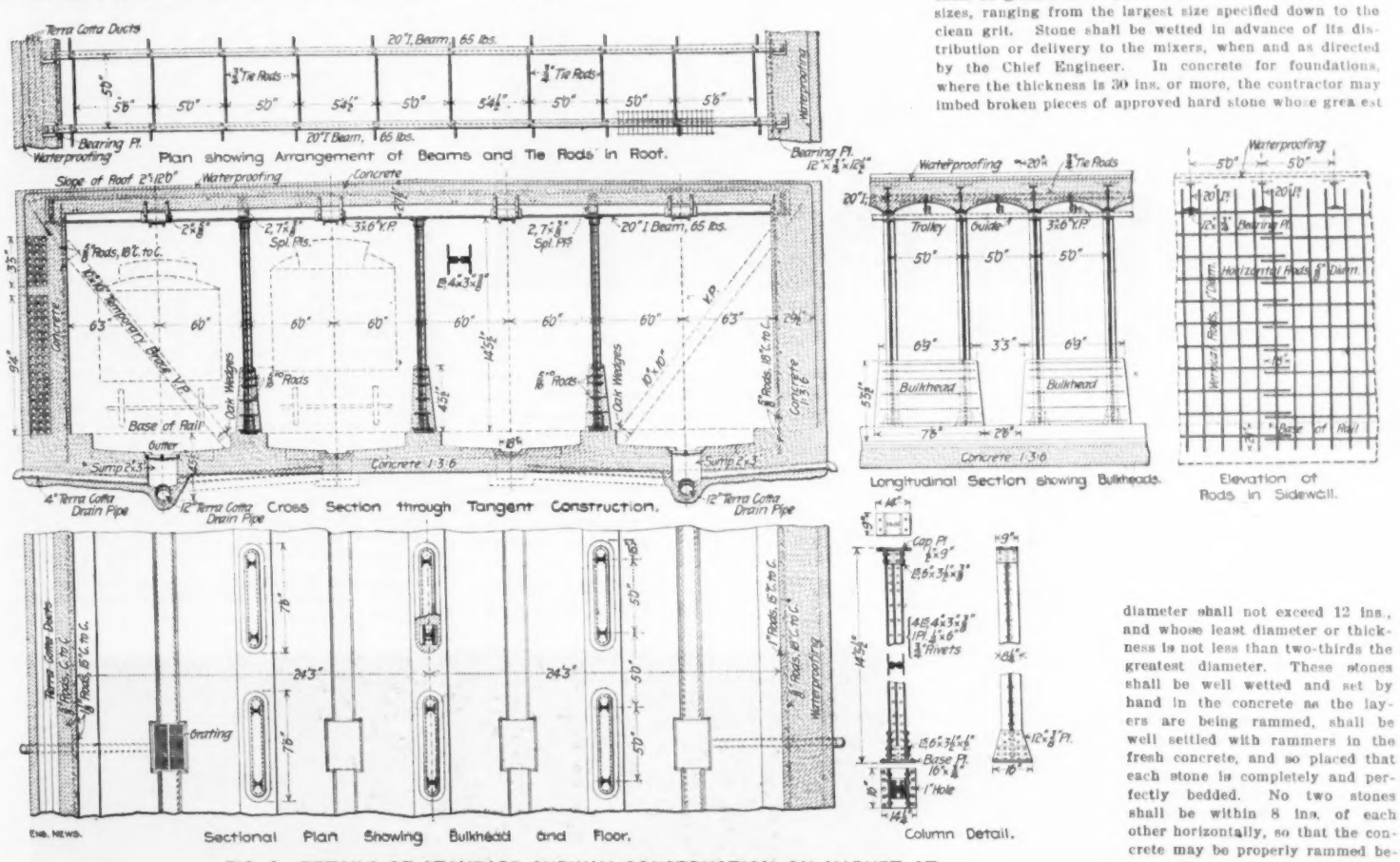

FIG. 3. DETAILS OF STANDARD SUBWAY CONSTRUCTION ON MARKET ST.

FIG. 4. VIEW OF THE COMPLETED PORTION OF THE SOUTH TRACK, SHOWING THE COMPLETED PORTION OF THE ROOF AND THE FINISHED CONCRETE SIDE WALLS.

ceed 6 ins., in a tight box or upon a proper floor, and be sprinkled with water as directed; the mortar is then to be evenly spread over the crushed stone, and the whole mass turned over a sufficient number of times, to effect the thorough mixing of the ingredients.

Concrete shall be laid immediately after mixing, in layers not more than 6 ins. in thickness, and be thoroughly compacted throughout the mass by ramming, until the water flushes to the surface. The amount of water to be used in making concrete shall be varied for the respective parts of the work as may be directed by the Chief Engineer. Especial care shall be taken in all cases to thoroughly consolidate concrete as deposited, and whenever in particular situations special tools are required for this purpose they shall be supplied by the contractor. Concrete required to be deposited in wet places shall be thoroughly protected so that the cement shall not be washed out. Before laying concrete on rock surfaces the latter shall be swept clean of all debris and dirt. Concrete shall be allowed to set for 12 hrs., or more if so directed, before any work shall be laid upon it; no walking or working shall be allowed on it while it is setting. Concrete shall be kept continuously wet until thoroughly hardened. When any concrete is added to concrete previously laid, in which the mortar has become set, the surface upon which the fresh concrete is to be placed shall be well washed and a thin layer of neat cement shall then be spread over it immediately previous to the laying of the fresh concrete. Concrete exposed to the sun shall be protected by necessary covering, to be approved, and so as to allow the wetting as before prescribed.

SURFACE FINISH OF CONCRETE.—In the successive placing of forms or contiguous sections of concrete work care should be taken so that there shall be no offsets or irregularities of any kind at joints between old and fresh concrete. Immediately after the forms are removed the surface of the work shall be thoroughly cleaned and wetted, and then brushed with a thin wash composed of 1 part Portland cement and 1 part clean, sharp sand, to be applied with vertical strokes of the brush, and so as to produce a uniform appearance. No plaster shall be placed upon the surface of any concrete, after the forms are removed, to produce a finish, but 1 or more additional brushings of the aforesaid wash shall be applied if necessary in any case to produce a proper finish. Care shall taken in the working of concrete against face forms, by the insertion of spatula, between the face forms and the concrete as it is being deposited so that the larger stones will be worked back from the face and the finer mixture flushed against the forms.

STEEL.—All wrought-steel shall be made the "open-hearth" process, and must be tough and ductile, of uniform quality and silky texture, straight and smooth, free from laminations, injurious surface defects, and must be made from uniform stock and have a workmanlike finish. Acid open-hearth steel shall not contain more than .08% phosphorus, and basic open-hearth steel not more than .05% phosphorus. Rivet steel shall be as follows: It shall have an ultimate strength of 50,000 to 60,000 lbs. per sq. in., an elastic limit 50% of the ultimate strength, elongation 26% in 8 ins., and bend 180° on itself, without fracture on the outside of the bent portion. All steel, other than rivet steel, shall be as follows: It shall have an ultimate strength of from 55,000 to 65,000 lbs. per sq. in., an elastic limit of 50% of the ultimate strength, elongation 25% in 8 ins., and bend 180° around a diameter the thickness of the piece tested, without sign of fracture on the outside of the bent portion.

CONTRACTORS AND ENGINEERS.—The subway work is being built by the E. E. Smith Contracting Co., of Philadelphia, Pa., as general contractors. Mr. W. S. Twining is Chief Engineer of the Philadelphia Rapid Transit Co., and Mr. Charles E. Mills is Principal Assistant Engineer. We are indebted to Mr. Twining for the information from which this description has been prepared.

BLOCK SIGNALS ON THE VANDALIA LINE.*

By Jno. L. Davis.†

The Vandalia Line, as you all know, is the small end of a funnel through which the Pennsylvania System pours its traffic into St. Louis.

About two and a half years ago when freight traffic was very heavy, we were trying to handle on certain portions of this line as many as 70 trains a day. We had worked into the business so gradually that we did not actually realize what a remarkable feat we were performing until our Superintendent, Mr. W. C. Downing, began to make comparisons, and found that we were actually handling as much traffic as certain double track lines west of Pittsburg. At the same time we did not have one inch of double track, not even through the yards at Indianapolis or Terre Haute or Effingham or East St. Louis. It was a single track railroad pure and simple.

All of a sudden, hardships began to rain on us thick and fast. The good luck with which the Vandalia Line is credited seemed to have left us entirely; our oldest and best conductors and enginemen forgot their orders and overlooked trains of superior right, and with very disastrous results. In one case an operator failed to deliver an order and caused one of the greatest disasters the Vandalia Line has ever seen in the way of a collision.

For twelve consecutive months we made an average of one collision in about every twenty days. After that year had passed, it seemed that the entire world had turned square against us. Everything that we tried to do failed. Our enginemen seemed to be afraid to run, and the trainmen seemed to be over-cautious in everything they did. Our passenger trains lost time from the moment they started out until they came in, causing delays without number to trains of lesser importance and those in turn delaying trains of still lesser importance. Our engine failures were numerous, and the mechanical department said that the failures were caused principally by the long number of hours that the trains were spending in side tracks; that an engine would leave the house in comparatively good shape, and before she reached the end of her run she was again a candidate for the shop. And, on the other hand, we said, if the engines were given to us in good condition we would move the traffic. Positive

*A paper read before the St. Louis Railway Club.
†Division Operator and Chief Train Dispatcher, Vandalia Line.

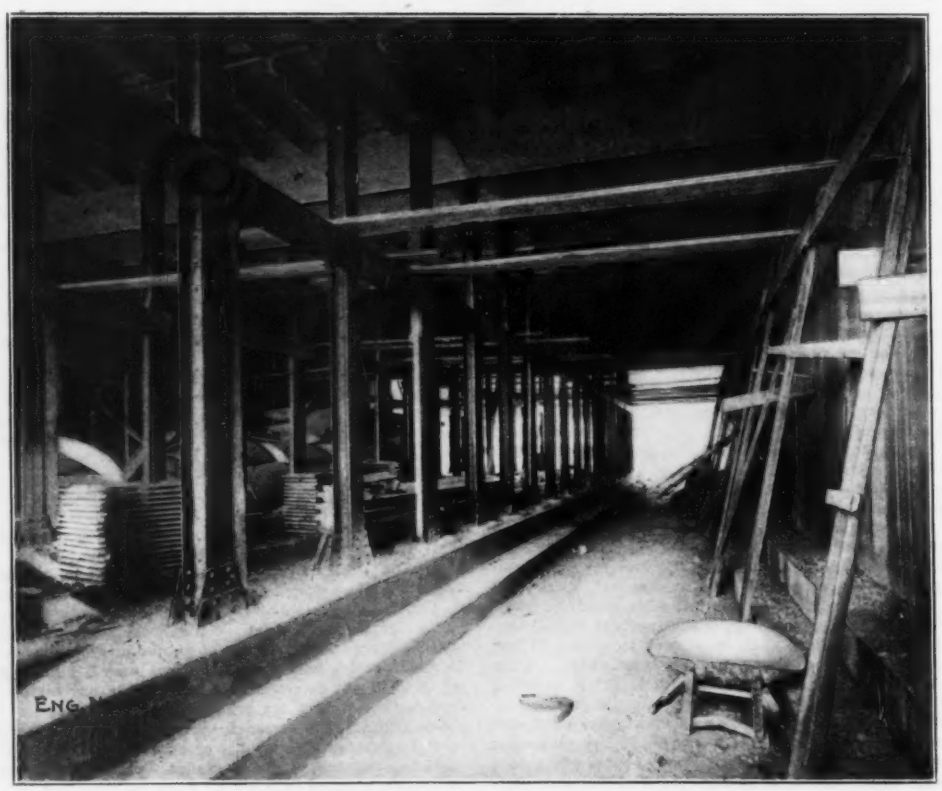

FIG. 5. INTERIOR VIEW OF SUBWAY UNDER CONSTRUCTION.

statements from either side of the fence did not improve matters a bit; we kept getting worse and worse until the side tracks and yards were congested to such an extent that there was very little room left for the meeting and passing of trains.

Our train dispatchers became discouraged because they were unable to keep up with their work. Mr. H. I. Miller, who is now General Manager of the Rock Island System, was then our General Manager. He and Mr. Downing, our Superintendent, got together and held conference after conference, and they agreed on one thing and decided that they would at least put an end to the collisions, and I was honored by being chosen as the proper person to investigate the different methods of signalling throughout the country and to advise them of the method which was in my opinion best suited to the needs of the Vandalia Line.

I commenced my investigations by going to the Chicago & Alton. I found that they had between Chicago and Bloomington at that time automatic semaphore signals to protect trains in both directions; the signals were operated on the normal danger plan, and were spaced anywhere from 4,000 to 17,000 ft.; on curves they were staggered, and at points where the view of the block signal was obstructed, a distant signal was placed in advance.

At all main track switches they used an annunciator in the form of an alarm bell. When a train approaching from either direction reaches a point 1,000 ft. beyond the first block signal, it will ring, and continue to ring until the train has passed the switch. Any one within hearing of the bell understands that the switch is not to be opened. Everybody connected with the property understands that. Their main track switches are all wired so that if a car moves out far enough to foul the main track, or if the switch points stand open as much as a quarter of an inch, the first block signal in either direction will indicate danger.

On this side of Bloomington they were working signals on the normal clear plan; they were located about 15 ft. from the block section so that the engineman could see the change from clear to danger, as he entered the block. If the signal failed to work properly, the engineman was to accept it as a danger signal. A broken wire or a broken rail or a train ahead in the block would cause the signal to indicate danger.

On all passenger trains they carry a speeder (a track velocipede.—Ed.) which is used only for the purpose of flagging. When they find a signal at danger, the flagman is immediately sent ahead five minutes before the departure of the train; then it proceeds at a rate of speed not greater than 15 miles an hour and continues in that way until a clear signal is found. They use hollow iron masts for their semaphore signals and the up and down rods are on the inside. The signals were made and erected by the Hall Signal Co., and are a credit to that company as well as to nearly any railroad.

On the Queen & Crescent a man can find pretty nearly everything he wants in the way of automatic signals to protect trains against following and opposing movements on a single track. They have the semaphore signal, the disk signal, the Banner or clock work signal, the shutter signal and two or three other kinds, all working very nicely.

One thing of particular interest to me on the Queen & Crescent was the English Staff System in use between Cincinnati and Ludlow yards and over the Ohio river bridge, and on three other short blocks.

A staff-machine is placed at each end of a block and the two connected electrically. The staff is a steel pipe, 22 ins. long, encircled with brass rings. At either end of it is stamped the names of the stations which bound the block. The staff serves two purposes: first, it is a key to unlock the levers which operate the signals; second, the possession of the staff gives to the train the absolute right of track over all other trains through the block. If the train consists of an engine only, the undivided staff is given to the engineman. If there is a conductor on the train the staff is divided; one portion is given to the engineman and the other portion is given to the conductor. They carry it through the block and deliver it to the operator at the other end. He immediately unites the two pieces by screwing them together and inserts it in his staff machine. The operators communicate with each other by a code of bell signals and in addition to that there is an indicator on each of the machines which shows whether or not a staff is missing. There is also a permissive system in connection with this method; it is performed by the use of what is called tablets; each tablet resembles an iron washer about 3 ins. in diameter, and the mechanism of the machines is of such nature as to make it impossible to use tablets on trains other than those running in the same direction as the one which has possession of the staff. This method of signalling seems to be safe, but unfortunately quite a reduction in speed is necessary in order to handle the staff properly.

Referring again to their electric signals, the installation is very similar to that of the Chicago & Alton. In fact, the work of installation was supervised by the same Signal Engineer, Mr. B. H. Mann. They use the C. & A. bell indicator, in all main track switches and use the C. & A. method of flagging. Now and then the flagmen will meet on their speeders, shake hands and compare orders, and find that some one has made a pretty serious error. The officers of the company are of the opinion that the automatic signals have saved for their company many times their cost by the prevention of collisions.

The Chicago, Milwaukee & St. Paul uses, between Chicago and Milwaukee, on the double track, the Rowell-Potter semaphore signals; on the Dubuque division they use a semaphore signal of the Union Switch & Signal Co. pattern. On all single track divisions, they use the manual block system to protect trains against following and opposing movement.

All high speed routes through interlocking plants are electrically locked, so when they are once set up, the route can not be easily changed. There is a hand release a short distance from the tower, but it takes the man a moment or two to go to it, and this requires some little time to turn it until the levers are released. The hand release is there, to be sure, so that the man may change the route in case the train for which it is lined up does not arrive when expected. Then, again, they have changed the method of signalling slightly from the interlocking plan, by blinding the lower light on the home signal, so that it appears only when the route is diverging. That is done to do away with running the enginemen up against a red light when the route is clear.

The Philadelphia & Reading uses Hall disk signals throughout; they are operated on the normal danger plan, and are spaced anywhere from a mile to a mile and a quarter, excepting in dangerous places, where they are closer together. They use iron masts extensively; there are two of the large disks on each mast; the upper disk shows red or white; and the lower disk shows green or white. When the upper disk is red, it must not be passed. When it is white, and the lower one is green, the train must proceed with caution. When both are white it means that the route is clear.

At all main track switches they use a disk indicator, which takes the place of and answers the same purpose as the alarm bell on the C. & A. and the Queen & Crescent.

Their train order signals are of the small semaphore pattern, and they are connected with the first block signal in either direction, so when train orders are to be delivered, the block signal indicates caution and the train comes into the station under control.

The present method of signalling on the Louisville Bridge, controlling trains between New Albany, Jeffersonville and Louisville was inaugurated at 12 o'clock noon, April 9, 1882 and has therefore been in service more than 22 years, during which time there has not been a failure of any kind on account of the method of blocking. They have a method of signalling where everything depends on the Train Dispatcher.

The operator announces the approach of the train, and the Train Dispatcher tells him what to do. The Dispatcher has before him a board about 3 ft. long, and probably 2 ft. wide, with the names of the stations reading from north and south in the center; on either side of the names of the stations are rows of holes, representing the schedules of trains. When a train starts from the north the Dispatcher places a white plug at the top of the schedule on which the train is to run, and he moves it downward one notch at a time in advance of the train.

When a train starts from the south he places a red plug at the bottom of the schedule upon which the train is to run, and moves that plug upward one notch or one block in advance of the train. In addition to that, he has before him a train sheet just as we have it in any other train dispatcher's office, upon which he records the time of all trains at the different stations. This gives him a double check on all train movements.

When a train approaches a station the operator announces the train number, and his office call, like this: "325 B. O." That means that train No. 325 is approaching Jeffersonville Junction over Block 3 and entering Block 4. The Dispatcher says "Red," "Green," "White," as the case may be, and the operator repeats that, which indicates also that the proper signal has been displayed.

Trains of all kinds and all cases are allowed to follow each other under permissive signal, through any block except Block 4, which has several pretty bad curves in it. During foggy weather the dispatchers use extra precautions to guard against trouble.

Another place where they run trains without orders is on the N. C. & St. L., around the foot of Lookout Mountain between Chattanooga and Wauhatchie, a distance of six miles, with two intermediate stations, making the blocks average about two miles in length. At each station there is a small interlocking plant, switches and signals of which are controlled by levers in the tower. When it is necessary for a train to take a siding, the Dispatcher tells the operator and the operator lines up switches and signals accordingly, and no orders are necessary. This method of signalling is very similar to that which I have described on the Louisville Bridge; in fact, it was copied by Mr. Thomas, who went to Louisville and spent some little time there and then returned to Chattanooga and put it into effect, with a few additional improvements and appliances, one of which is an arrangement so that when a train enters the block and the operator pulls the signal to clear, a red disk falls in front of the operator's face; one also falls in front of the face of the operator at the other end of the block. If an operator, by mistake, pulls the signal to clear while the disk shows red, meaning that the block is already occupied, he will be instantly reminded of his mistake by an alarm bell which is located directly over his head, and which commences to ring and continues to ring until the train is out of the block, or until the signal has been returned to normal danger.

This method of signalling is almost ideal; it means that there is a way to run trains by visible signals only, with no written orders of any kind.

Another place where the Train Dispatcher directs the handling of the block system is on the Erie, where they use what is called the Mozier Block System. It was inaugurated June 14, 1893, and the record that the Erie people have made with it is something to be proud of. During the Chicago World's Fair the Erie held second place in the number of passengers handled into and out of Chicago, and while they handled that immense volume of traffic, not a single personal injury of any kind or description did they inflict upon a patron of that road. They run trains by train orders, with train rights and train rules, just as they did before they had the block system. It is only an additional precaution. The operators announce the approach of a train and the Dispatcher says what kind of a signal to display. They use three-position semaphore signals—horizontal, red, means danger; elevated, green, means caution; depressed, white, means safety.

The signals are connected with the telegraph keys so that it is impossible for the operator to answer his call or do any business on the telegraph wires while his signal is at a caution or at safety; it must be at normal danger before he can do any business on the wire at all.

Something brand new in the way of signalling is that which is now in effect on the Illinois Central, between Belleville and Carbondale, Illinois, and between Paducah and Central City, Kentucky. I never heard of it until a short time ago, when our present General Manager, Mr. Benjamin McKeen, spoke of it and asked me to investigate its workings. They call it a positive block signal system, and they have a method of carding which makes it very flexible; and almost the same as the permissive block system.

The signals are of the semaphore pattern, with two positions only. The principal thing of interest connected with this method of blocking is the blocking machine, the like of which I have never seen anywhere. The signals return to normal danger by gravity and are instantly locked automatically. Then it is impossible for a man to pull his signal to clear until the operator at the other end of the block has unlocked the signal for him.

I am unable to say to whom should be given the credit for this excellent method of locking, but I understand it originated with Mr. I. G. Rawn, of Chicago, and that it was developed and put into practice by his Superintendent of Telegraph, Mr. G. H. Groce. The machines are made by the General Railway Signal Co.

I think this machine has given us a great move in the right direction.

After I had given the matter what I considered due time and consideration, I was of the opinion that we deeded automatic semaphore signals, to protect trains against following and opposing movements on the Vandalia Line, but an estimate of the cost killed it.

My second choice was the manual block system to give the same protection. For some little time we hung fire between the Mozier and the American Railway Association—and after weighing very carefully the strong and weak point of each of those methods, we decided in favor of the latter, and took liberties only where such liberties are made permissible by American Railway Association. In these places I inserted rules that were applicable to our division; they were passed upon and approved with very little alteration. Mr. Downing then turned over to me the work of installation, and immediately we set out to install the block system. Just as fast as the towers were completed it was installed, but never more than five towers at a time for the reason that we have only three offices on each section of the block wire and I could be at the central office and watch the work on the two blocks, until I knew positively that each and every one of the operators knew exactly what to do under any and all circumstances before extending the block system over that portion of our road. With this method we depend entirely upon the telegraph operators. They work on a separate wire, and the work of blocking takes preference over any and all other duties. Three position semaphore signals are used, and a train is protected over every inch of its journey. Each operator has before him a block record, upon which he records the time of all trains at his station, and also records the time at which trains enter and clear the block at the first station on either side of him. Before the clear signal is given, the operators have a positive understanding that the move will be protected. Trains are run by train rights and train orders and train rules, just as they were before we had the block system. It is only an additional precaution, and gives us a separate organization of men checking against any error that may be made by any conductor or engineman or train dispatcher.

Before the work of installation was entirely completed there was noticeable a great difference in the movement of

our trains; it seemed the men realized all at once that they were protected, and faster time resulted from that time on. Our over-time began to decrease and continues to decrease. During the months of August and September of this year we decreased in our over-time to the extent of $1,500 for each of these months, as compared with the same months of last year.

The actual figures taken from our train sheets show that the number of freight trains handled in the six months, ending with September 30, 1904, decreased 301 over the corresponding period of last year, and at the same time, the number of passenger trains run increased 923.

With that enormous increase in passenger traffic, it would only be reasonable to expect slower movement on a single track road, but I have gone into it carefully, and can state positively that the movement of our freight trains and the movement of our passenger trains has been accelerated to a remarkable degree.

During the period mentioned, six months of last year we handled 2,637 passenger trains, and the average time of these trains was a little less than 36 miles per hour, including all stops and delays. During the same period of this year we have handled 3,560 passenger trains and the average time was 37.3 miles per hour, including all stops and delays. Our banner month was June, 1904, when we handled 593 passenger trains, and the average time of those trains was 41.1 miles per hour, including all stops and delays.

I must not forget to say that the condition of our motive power is better and that we have additional facilities in the way of a second track through Indianapolis yards, 2.5 miles; around Terre Haute East yards, 3 miles; and, from Collinsville into East St. Louis, 10.8 miles. Those improvements have been of very great help to us, and it is not the intention to take a grain of credit from any other department. I feel that each ought to have whatever is due; at the same time, we can give them due credit and still there will be enough glory left for the manual block signal system to recommend it for use on nearly any single track railroad in existence.

I may have given out a wrong impression in the fore part of my remarks regarding the number of accidents we have had on the Vandalia line; and if such is the case, I want to correct it right here, because we hold a record that is probably second to none, when it comes to casualties. Listen: On Jan. 28, 1895, Mr. John W. Norton, a prominent citizen of St. Louis, was killed at Coatesville, Indiana, 28 miles outside of Indianapolis, when train No. 20 left the track on account of a broken rail. He is the only passenger who ever paid fare to ride over the Vandalia line that was killed in a train accident, although the road has been in operation for more than a half century.

I feel that the manual block system will grow in popularity much more than the automatic, for single track lines, for the reason that the men who handle it are of great assistance in the handling of trains.

There must be an operator at every siding, and all of you transportation men who know just exactly what it means to be able to give to a train five or ten minutes additional time; under certain circumstances, it may amount to hours before the end of the trip. That is why the manual block signal system accelerates train movement, reduces over-time and increases the capacity of a single track railroad.

THE THREE-POINT PROBLEM IN PLANE-TABLE SURVEYING.

By Antonio Llano.*

The three-point problem is of constant occurrence in plane-table surveying. It may be stated thus: The plane table being set over a point from which are visible three other points whose positions have been already platted on the sheet, it is required to determine the platted position of the point occupied.

Several methods have been devised for the graphic solution of this problem in the field. They may be found in the Annual Report of the United States Coast and Geodetic Survey for 1880. Of these, Bessel's method is the simplest and most elegant. It is described here, as it seems that several text-book writers have entirely misunderstood it, confounding the field operations by which the problem is solved with the geometrical construction employed in demonstrating the correctness of those operations. Those writers have given this geometrical construction as being itself the field solution, thus mixing up matters and depriving the method of its simplicity. After describing Bessel's method, the writer will describe a method of his own, which he thinks is very convenient and expeditious, and perhaps of wider application than Bessel's.

In the first place, it is well to observe that in plane-table work the instrument is treated as a point. If the board is clamped, and the alidade is directed to a distant object, the line of sight is assumed to have the same direction whatever the position of the alidade on the board. In other words, it is assumed that the lines determined by directing the alidade towards the distant object from different points on the board are parallel. Thus, in Fig. 1, the lines P A and P' A obtained by placing the alidade in contact with the points P and P', respectively, and directing it to a distant point A are treated as parallel lines. The usual conditions obtaining in plane-table work are such that this assumption causes no appreciable error.

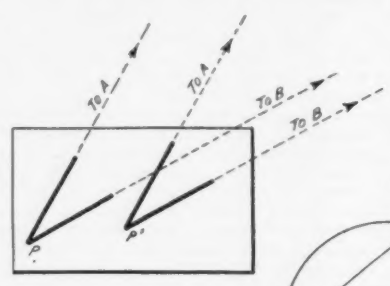

Fig. 1.

It follows that if, with the alidade in contact with a point P, two lines of sight are directed to two distant objects A and B, the angle A P B thus obtained is the same as that obtained by placing the alidade in contact with any other point, as P'; and this angle is referred to as the angle made by the two lines from the objects A and B to the "point" occupied by the plane table. In other words, if the position of the plane table is denoted by D, the angle A D B is determined by placing the alidade in contact with any point of the sheet on the board and directing the line of sight first to one and then to the other of the objects A and B.

Bessel's method is founded on the principle that in any inscribed quadrilateral the angle made by one of the sides with one of the diagonals is equal to the angle made by the opposite side with the other diagonal. Thus, in Fig. 2, angle e a c is equal to e d c, and e c a to e d a. This follows from the fact that the angles 1 are both measured by half the arc a e, and the angles 2 by half the arc c e. Conversely, if through one of the vertices, as d, of a triangle a d c, a line d e is drawn making any angles 1 and 2 with the sides d a and d c, respectively, and lines are drawn from c and a, making the same angles, respectively, with ac, then these two lines will meet d e in the same point.

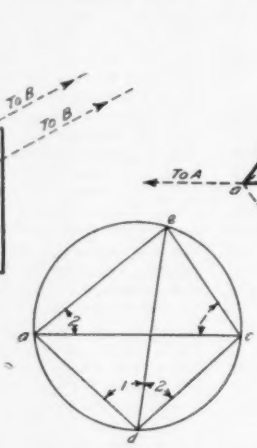

Fig. 2.

Let a, b, c, Fig. 3, be the platted positions of three points, A, B, C. As usual, points on the ground will be denoted by capital letters, and their platted positions by the corresponding small letters. The point occupied will be denoted by D, and its platted position (to be determined) by d. The heavy lines joining the points a, b, c, are here drawn for clearness, but are not needed in the field solution. If the angles A D B and C D B are determined, the point d will be located by drawing from a and c two lines such that, by joining their point of intersection d with b, the angles a d b and c d b shall be equal to A D B and C D B, respectively. In Bessel's method the angles A D B and C D B are determined thus: The edge of the alidade is placed on c a, and the table turned till the line of sight is directed to A, as indicated in the figure. The board is then clamped, and, with the alidade in contact with c, the line of sight is directed to B, and a line c e is drawn along the edge of the ruler. The angle a c e or A c B thus determined is obviously equal to the angle A D B, since the point c, like any other point on the board, is assumed to be over D. In the same manner, the alidade being placed along a c, the board is turned till the line of sight is directed to C. The board is then clamped, the line of sight is directed along a B, and the line a e drawn along the edge of the ruler. The angle c a e, or C a B, is then equal to C D B. Now, the line d b makes with d a and d c, respectively, angles equal to A D B and C D B; therefore, as explained above, the point e where a e and c e intersect must be on db; and conversely, if the line b e is drawn and produced, it must pass through d. Let, then, an indefinite line b e d' be drawn through b and e. The position of d on this line is determined by drawing a line from a, making with d' b an angle equal to A D B. To do this, place the alidade on d' b, and direct the line of sight to B. Clamp the board, and direct the line of sight along a A. A line drawn along the edge of the ruler in that position will make with d' b an angle equal to A D B, and, therefore, intersect d' b at the required point d. To check the position of the point d, the alidade is turned till the ruler coincides with d c, in which position the telescope should point towards C.

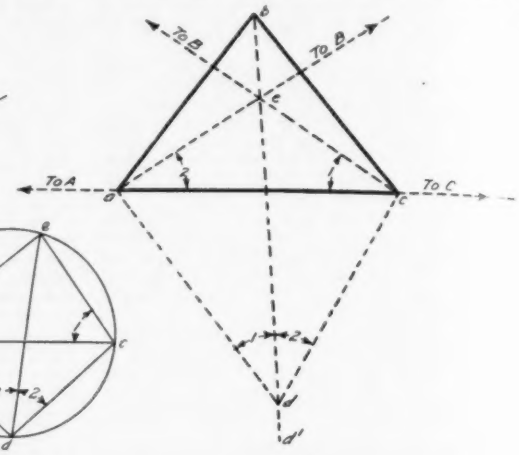

Fig. 3.

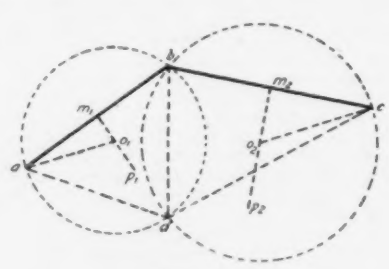

Fig. 4.

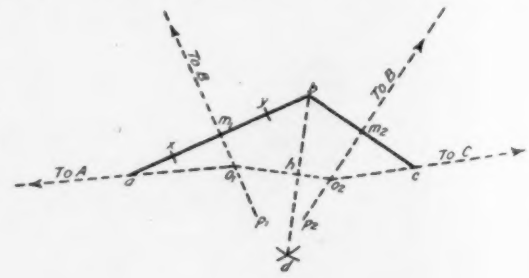

Fig. 5.

The field operations may be stated in the form of a rule thus:

1. Place the alidade on c a, direct the line of sight to A, and clamp the board.
2. Direct the line of sight along c B, and draw ce along the edge of the ruler.
3. Unclamp the board, place the alidade on ac, direct the line of sight to C, and clamp.
4. Direct the line of sight along a B, and mark its intersection e with c e.
5. Draw b d' through b and e.
6. Unclamp, place alidade on d' b, direct line of sight to B, and clamp.

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7. Direct line of sight along aA, and mark its intersection d with bd'.

8. Place alidade along d c, and see if the line of sight points towards C.

The objection to Bessel's method is that in a great many cases the point e falls either too far from b (sometimes outside the board), or too near b. In the latter case, the line b e d' cannot be accurately drawn.

The writer's method is founded on the following elementary principles: The notation being similar to that of Fig. 3, the point d, Fig. 4, is at the intersection of two arcs described on a b and b c, capable of containing, respectively, the angles A D B and C D B. If these angles are known, one way to find the centers of the arcs is as follows: Draw the perpendicular $m_1 p_1$ at the middle point of a b, and from a draw a line a o_1, making with this perpendicular an angle equal to A D B. The point o_1 is the center, and o_1 a the radius, of the arc described on ab capable of containing the angle A D B. For, any angle inscribed in the arc a d b thus described is measured by half the arc a b, and is, therefore, equal to a o_1 m_1, or A D B. The center o_2 and radius o_2 c are similarly found.

The application of these principles to the field solution of the three-point problem is exceedingly simple. Referring to Fig. 5, the lines a b and b c are bisected by the perpendiculars $m_1 p_1$ and $m_2 p_2$, respectively. If they are inconveniently long, equal distances may be marked off from the extremities, and the remaining part bisected. Thus, to bisect ab, the points x and y, equidistant from the ends, are marked, and the sect x y is bisected by the perpendicular $m_1 p_1$. The edge of the alidade is placed on $p_1 m_1$, and the board is turned till the line of sight is directed to the intermediate point B. The board is then clamped, the line of sight is directed along a A, and its point of intersection o_1 with $m_1 p_1$ is marked. Then, a $o_1 m_1$ = A D B, and o_1 is the center of the arc to be described on ab. Similarly, the alidade is placed on $p_2 m_2$, the line of sight directed to the intermediate point B, and the board clamped. The line of sight is then directed along cC, and its intersection o_2 with $m_2 p_2$ is marked. The angle c o_2 m_2 = C D B, and o_2 is the center of the arc to be described on bc. The point d may be determined by the intersection of two arcs described from o_1 and o_2 with radii o_1 a and o_2 c, respectively. If the radii are inconveniently long, d is determined by drawing from b a perpendicular bh on $o_1 o_2$, and producing it so as to make hd = bh. This follows from the fact that bd, being a common chord of two intersecting circles, is bisected by the line $o_1 o_2$ joining the centers of the circles.

This second method of locating d is preferable in a great many cases, its main advantage being that it requires no compasses.

NOTES OF AN ENGINEER IN JAPAN.

By W. E. Crane.

Japan is composed of 3,800 different islands, of which the four largest—Honshiu, Shikou, Kiushiu and Yezzo—constitute Japan proper. The islands are extremely mountainous, and of volcanic nature, some volcanoes being still active.

The rivers are very numerous, but of short length, and there are none navigable. The streams widen out from the foot of the mountain to the sea. At present (in the month of August) the beds are perfectly dry.

IRRIGATION.—The whole available low land of Japan is one vast field of rice cultivation, which requires water. Irrigation has been carried on for centuries. The streams are controlled between high banks, thrown up on either side, sometimes to a height of 20 ft or more; and in most instances built some feet back from the river bank proper. These banks have been constructed with great care, are thoroughly grassed over, and in many instances there are heavy growths of trees upon them. The sedimentary deposits brought down from the mountains has filled the river bed between these banks, so that in many instances the present bed of the stream is many feet higher than the level of the adjacent valley.

Across the valleys, great embankments have been constructed, extending from the river embankments—sometimes across, sometimes along the river for miles. The center of these embankments constitutes a great ditch, and upon either or both sides are constructed the highways of the country. Lateral ditches and highways are constructed at favorable locations. Thus the whole area is networked with these ditches and highways, and one is amazed at the great amount of work that has been done.

Higher up in the hills, storage reservoirs are constructed wherever a suitable location is found. The flow of the rivers is therefore diverted into the ditches or held in the reservoirs. Very little stream flow reaches the ocean.

The rice fields are generally arranged according to the configuration of the ground into fields, many of exceedingly small area. The flooding (irrigating) of these fields is done in several ways: sometimes by direct flow from the ditches, and in places by raising water from a storage well, with bucket and well-sweep.

To raise water from the ditches to a slight elevation there is used a small water wheel. The wheel is about 4 ft. in diameter. It works in a box in the shape of a quadrant of a circle. The box is placed in the ditch, between two guides (bamboo poles) and the wheel in the box. Upon the edge of the blade of the wheel a strip is fastened. The wheel is worked as a treadmill, the men or women who tread the wheel supporting themselves by holding to the bamboo poles. The laborer moves from one field to another, carrying the wheel and frame as one load, suspended from the ends of the poles thrown over the shoulder. Where the height is considerable, several wheels are worked at one location.

CANALS.—The coast line is so very irregular and has such deep inlets that the larger cities are located along the sea coast. In all these cities there are canals with numerous basins used as waterways for transporting all kinds of produce, merchandise, fuel and building materials. The transportation is done in junks, flatboats and in some instances in steam-propelled craft.

In nearly all instances the banks of the canals are constructed of a good class of granite masonry walls.

RAILROADS.—Japan has a complete system of railroads around the larger islands, with numerous branch lines crossing the island. Completing links are being built, and new branches extended. Stations and railroad terminals are being enlarged. At Nagasaki the station at present is fully one mile from the harbor custom house. This intervening space has all been cleared and graded streets laid out and paved, and plans made for a new station on the Bund. Work is progressing and when completed will have cost over $1,000,000 gold. In Tokio an elevated four-line track is begun and is a fine piece of brick arch masonry work. The station buildings are airy, roomy and well constructed, a far better class of structures than is usually found on our American railroads, either east or west. There are ticket offices and separate waiting rooms for first, second and third-class passengers.

Owing to the plan of constructing the river embankments back some little distance from the river bank, nearly all stream crossings are very wide. Many have twenty or more spans, the distance being from 1,200 to 2,000 ft. The general types used are plate-girder spans, and the Pratt and Warren type pin-connected spans. I have not noticed a riveted lattice girder span. The piers and abutments are usually of first-class granite masonry, presumably on pile foundations. The streams are so numerous that the bridging forms an important item in construction. The equipment consists of English, German and American types, the newest cars of American type. All freight cars are of English pattern and locomotives and cars have the English style of coupler. Sleeping and dining cars are of American pattern. Cars are supplied with electric lights. The switch and signal system in general does not seem to be up to the best modern practice. Tracks are narrow gage, and rails light. In coaling engines, small baskets of coal are thrown on to the tender and emptied. Baskets hold less than a half bushel, and the coaling process is slow. The railroads are owned and operated by both the Government and private corporations.

HIGHWAYS AND BRIDGES.—I have seen nothing in Japan in the way of paving other than macadam. The streets are paved from gutter to gutter, usually without any crowning. Both in old and new work, gutters are built on the lot or building line, a square gutter 12 ins. wide and 12 ins. to 20 ins. in depth. Each property owner sweeps the street in front of his property, and also sprinkles it. This last is done at all hours with a vengeance, simply by throwing many buckets full of water in the street, so that it is usually one continuous mud puddle. In some of the cities public sprinkling carts are drawn through the principal streets. These are usually a two-wheeled cart with tank having auger holes in the bottom.

WATER SUPPLY.—The large cities and even the country villages usually have a good water supply. Hydrants are plentiful and practically every house has its private water supply. Open wells are located frequently along the streets, and every temple enclosure has a good well from which water is obtained.

The water supply is furnished from reservoirs located in some of the valleys adjacent to the cities, Nagasaki having three such reservoirs. At one of these is a finely built granite masonry dam. The water is practically unpolluted. Water is used freely both in public and private consumption, and is furnished very cheaply to the private consumer. Meters are in use in many houses, but the rate is generally so much per month. A hotel here with eleven taps pays 60 cts. (gold) per month.

SANITATION.—Japan has made little progress in sewerage and sanitary construction.

In the country and small villages the small streams are polluted; the people bathe in and do their washing in small ponds of very stagnant water.

Both in city and village, small gutters are built along the lot line, which are supposed to be covered with flagging, but in many instances they are covered with loose boards, and in the narrow streets and poorer quarters there is no covering at all. These gutters have become so clogged with filth and street sweepings that there is no flow whatever.

The street gutter terminates usually in some small stream or (in the cities) in the canals.

Practically all canals are subject to tidal flow, and at ebb tide the bottoms of the canals are exposed. At this time the stench is fearful, worse than the Chicago or Milwaukee Rivers in the later '80's.

The water closet arrangement is simply a receptacle (usually earthenware) which is emptied occasionally, the contents being carried away in closed barrels. Imagine Tokio, a city of 2,000,000 people and an untold number of houses, and this cleaning of closets going on day and night. In the streets, one's sense of smell soon informs him that he is passing one of the so loaded carts or carriers. The contents of the vaults are carried into the environs and deposited in earthenware open wells, located usually at the corner of each garden, to be used later as fertilizer. It is not unusual to meet or pass by women and even young girls carrying two heavy buckets filled with this refuse, carried two miles and even more from the city.

There is usually no charge for this cleaning of vaults—the farmer or gardener even offering a small fee in way of vegetables for the privilege of cleaning them. The Japanese are very cleanly in person. Within their houses everything is washed and scrubbed and polished; but outside the walls of the house is the most disgusting filth.

In the country the same method is employed, excepting that they seldom cover the barrels while carting to the fields.

GARBAGE DISPOSAL.—The small streams and the canals are used as repositories for decayed fruit, vegetables, etc. Small wooden boxes are placed at different points along the streets to receive refuse material. Collections are made (probably at stated times) from these boxes, and carted to an enclosure along the bank of the canal. The material is sorted over and loaded on flat boats and taken to the fields. Occasionally the

gutters are cleaned and the refuse deposited and hauled away as is the garbage.

BUILDINGS.—Many new modern structures of granite and brick with granite facings are being constructed in the larger cities. Usually the houses are constructed of wood. In the country and in small villages, even in the poorer sections of large cities, the houses are built of bamboo poles and the walls plastered with mud, both inside and outside.

Japan is supplied with granite, limestone, sandstone, andesite rock and tuffa stone. The granite is used in buildings, bridges, sea-wall construction, in canal work, and has a beautiful appearance. There is a conglomerate sandstone found near the coast that is used a great deal in canal wall construction. It hardens on exposure to air. Brick is made of a size somewhat larger than the American standard size, and of a quality equal to American paving brick. Pine is the wood mostly used, excepting perhaps bamboo.

A great amount of concrete is used, including cornice work, window sills, coping, etc. Walls of large buildings and foundations are made of concrete. River gravel is used instead of broken stone. This is easily obtained and transported by boat along the canals.

TRANSPORTATION.—There are practically no highways in Japan. Roadways are narrow. They only allow of the passing of Jinrikishas and small carts. Paths wind here and there along the mountain sides, and all kinds of material, goods, etc., are transported on the shoulders of men and women, while bullocks, cows and horses are used as pack animals. Across country and in the city small two-wheeled push carts are used, and also carts hauled by horses and cattle.

LABOR IN CONSTRUCTION.—Were it not for cheap labor, the cost of construction for any class of engineering work would be very great. In building earth embankments, dump cars (that do not dump) are used. The box of the car is loose on the car trucks, and when ready to dump usually three men with levers labor and strain and finally succeed in overturning the car and load. For short haul, less than, say, 300 ft., the material is hoed into a basket shaped like a scoop shovel, emptied into a sling, and two men carry the load and dump in the embankment.

In pile driving, the pile is driven by means of a wooden hammer faced with iron. The hammer is raised between two bamboo guide poles. The power used is from six to twenty men pulling down on ropes attached to the hammer rope which passes over a pulley.

In washing gravel, a large tub of water is placed beside the pile of gravel. One man puts a shovelful of gravel into a small basket held by a second man, who dips the basket of gravel into the tub of water, drains it and throws it to one side in a second pile. A third man carries water, cleans and changes the tubs.

Water is carried in buckets suspended from a pole thrown over the shoulders. Mortar and concrete when mixed is delivered in the same way.

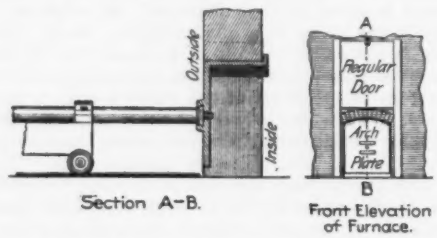
The workman is very slow, but precise. The work when completed is practically first class in every respect. There is no question as to the quality of Japanese workmanship.

COST OF LABOR AND LIVING.—So much of the transportation work is done by individual contract that it is hard to place any definite price on this class of labor. The same may be said about farm laborers. When employed, they receive from $2 per month up with board. The ordinary laborer on railroad and municipal work receives from 20 cts. to 35 cts. per day. A mason or stone cutter gets from 40 cts. to 60 cts. per day. The engineer on a locomotive gets about $35 per month, the fireman about $20 per month. A Japanese gentleman who has been for years in California (now retired here in Japan) is building many houses. He states that he has five good carpenters at work for him at 25 cts. per day. For domestic labor both men and women get $1.50 per month and board. Women labor on the streets, and at the work of coaling ships are paid about 20 cts. per day.

During the China-Japan war, prices for foods advanced, and after the war did not return to former prices. Since the present war with Russia began, prices have again gone up and now are fully five times as much as before the China-Japan war. The compensation to labor has advanced very little, if any. Living, however, is still very cheap.

A TIME-SAVING DEVICE FOR STEEL FURNACE WORK.

The simple device shown in the illustration herewith merits attention as an example of the simplicity of means which may be instrumental in producing large savings. The purpose of the device is to cut down certain losses of time which occur in steel furnace working, and its importance is therefore measured not by the value of the labor directly involved in its use but by the value of the labor and capital which wait on its work. To keep a steel furnace waiting for an hour while it might be turning out many tons of product means a loss which has no relation to the



direct cost of the work which causes the wait; conversely, if the time of wait can be largely reduced, the total gain is many times greater than the labor cost directly saved.

The Johnson Arch-Plate for furnaces is intended to facilitate the repair of charging-door openings. In the operation of mechanical charging, by means of a charging machine, the brick arch over the opening is often struck or grazed, and in consequence needs frequent repair. To make such repair possible, a temporary shield or bulkhead of brick has to be set up inside the opening as a protection to the workmen from the heat while renewing the arch. Setting up this bulkhead, by long-handled tools, is particularly slow and awkward work. The new device saves this work by providing a steel bulkhead which may be quickly set and held in place by the charging machine. It also forms a center for the arch, so that the work of setting the arch brick is expedited.

Its construction is so simple as to require no explanation. A pair of lugs on the outside of the main plate is adapted to grip the nose of the ram of the charging machine. The upturned lip on the inside of the horizontal arch-shaped part of the plate forms a stop against which the arch brick are laid.

The door openings being generally of uniform size, a single arch-plate suffices for an ordinary plant. When a door arch is to be repaired, the plate is fixed on the ram, the regular sliding door is raised out of the way, and the arch-plate is introduced and raised into place. After the brickwork is completed, the plate is lowered to clear the inside rib under the arch and is withdrawn, leaving the furnace ready to continue work.

This arch-plate has been patented broadly as a combined arch-plate and shield, by Mr. Frederick Johnson, of South Chicago, Ill. It is made by the Wellman-Seaver-Morgan Company, of Cleveland, O.

SOME POINTS IN THE ECONOMICAL HANDLING OF LOCOMOTIVES.*

By T. J. Henderson.

Many railroads are offering inducements to the enginemen to save or economize in the use of fuel. Some figure that if a saving of only one shovelful of coal, or a gallon of oil, on each engine every day, could be made, at the end of the year many hundreds of dollars will be to the company's credit which would otherwise be lost. I venture to say that there is not a single engine running to-day on which a daily saving of not one, but many, shovelsful of coal and gallons of oil, may not be realized if the enginemen only will try. "We can all do better if we try."

It is a generally known fact that, in England, the English locomotives will do almost twice the amount of work on the same quantity and quality of fuel that our American engines will do or do do. Here is what an English engineer says of an engine-driver: "There is," he says, "an idea abroad that unless the steam is blowing off madly through the safety-valve there can be no great demonstration of skilled enginemanship." There can be no greater mistake, for, when steam, water, and fuel are blown away through the pop-valve, it is a positive proof of the existence of either one or both of the following evils: The engine is too small for the work, or it is too great for the men.

Let us see what this waste through the pop-valve amounts to. By an actual test on a locomotive at Purdue University, it was found that, by blowing off steam through the safety-valve for four consecutive minutes, 6 cu. ft. of water, 336 lbs., was converted into steam and blown away, being at the rate of 84 lbs. of water per minute, 1 2-5 lbs. per second. In ordinary work, 6 lbs. of water are converted into steam for each pound of coal consumed, and about 12 lbs. per pound of crude oil. The amount of coal wasted in four minutes was 56 lbs., one-quarter of a pound per second. In forty seconds 10 lbs,. or one shovelful of coal, would be wasted.

To get a proper understanding of the fuel economy question, many things we must consider in order to intelligently discuss the subject: 1. A well-designed engine, that is, a properly-adjusted draft appliance, with the cylinders not any larger than the boiler; 2. A well-kept engine; 3. Properly supplying the boiler with water and the fire with fuel; 4. Smooth, steady running; and last, but not least, not too great a distance between the engineer and conductor.

If an engine's cylinders are too large for the boiler; the boiler too large for the firebox and heating surfaces; the nozzle improperly adjusted; cylinders, valves, steam pipes, and joints blowing; or valve motion out of order; it is next to impossible for any kind of engineer or fireman to make a good record with her. Smooth, steady running two-thirds of a good coal record can always be traced to the engineer who is intelligent and takes an interest in performing his duties well. If the engineer takes no interest, the fireman will be compelled to take things as they are, and will very likely be blamed for the engineer's ignorance or carelessness.

There are two kinds of engineers, and likewise two kinds of firemen; therefore, there are two ways of running and two ways of firing a locomotive. Some men would not make good, economical engineers with unlimited experience. Some will try to make up all the time they are behind in the first two or three miles, and will try hard to make it up before they get out of the yard limits; others, again, will leave on time, on a moderately fast run, and will run as fast as they can to the next town, but finding, by consulting their watch, that they are going to arrive too soon, they shut off, regardless of the high steam pressure and big fire, and away goes the steam through the pop. The process is repeated between every station. The fireman has to fire the engine so that when they are leaving town he will have a fire that will stand the conditions; he is determined to keep her hot, if it takes all the coal in the coal pit; then, when the throttle is again shut off, the safety-valve screams with joy.

There is another kind of engineer that does not prove a success at the business; he may not be a hard hitter, but will let the balance-packing blow, pistons and rods leak, steam pipes and joints leak, nozzles get loose or choke up, and so on, and should the fireman make any suggestions as to the cause or cure, he will likely be told he is firing her too heavy, the fire is full of holes, or something else; perhaps he will be informed he is not paid for running the engine, or he knows too much. Such an engineer will be afraid to make a report, for he may not know what to report. His engine runs down and becomes a poor steamer, and will burn all the coal a fireman can shovel into the firebox. Others will have no confidence in themselves, or their engine's ability, and on a hill or heavy train will want her popping all the time, claiming they can not pull cars with cold water. Others will make a run for a hill like a boy running a mile to jump over a two-board fence, and are out of wind when they get there.

The economical engineer is one who will do the right thing at the right time with the least possible amount of steam going through the cylinders, and has confidence in his engine's and his own ability, never gets in a hurry and is generally on time.

*An extract from a paper read before the Pacific Coast Railway Club at San Francisco, Cal., Oct. 15, 1904.

PUMPING GAS TAR is being successfully accomplished at the Maryland Steel Co.'s plant, Sparrows Point, Md. The pumps were built by the Deane Steam Pump Co., of Holyoke, Mass., and are of the triplex type, fitted with ball valves. The pump is driven by a 3-HP. alternating current motor, carrying a Renold silent chain, which runs at a speed of 950 ft. per minute and drives a balance wheel on the same shaft with an 18-tooth spur gear. This smaller gear meshes with a 120-tooth gear on the main pump shaft.

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The cement used in modern engineering works is almost invariably purchased under specification. This procedure implies the testing of the material upon reception; in fact, most cement specifications state definitely that tests will be made to determine the fitness of the material supplied to meet the requirements. It is not uncommon, however, to find omitted all definite mention of the manner in which these tests shall be conducted. Ordinarily no difficulty arises from this omission. It is tacitly assumed by the manufacturer and the purchaser that the ordinary modes of procedure will prevail; and, in fact, so long as the cement meets the tests, there is little disposition on the part of the first party to make complaint even if uncommon methods of manipulation are practiced by the engineer. Let a doubt arise, however, about the cement meeting the tests, particularly if it may involve the probable rejection of considerable shipments of delivered material, and the manufacturer will most certainly dispute the justice of any variation from prevailing practice in manipulating cement tests, and, if the emergency is pressing, he may go even farther and insist on his own interpretation of what is proper practice. A case of the last-mentioned character is called to our attention in the following communication:

> Sir: Some time ago a certain brand of cement was brought in to be tested. It did not give satisfactory results either in the pat tests or in tension. The manufacturer was not satisfied, and, after some correspondence had passed, sent a representative here to "show" us how to test cements. Said representative used methods that I had never before understood as allowed. He tamped the cement as thoroughly as possible with the handle of a heavy trowel also frequently striking the molds with the flat of the trowel very hard in order to make the briquette as dense as possible. On being questioned as to the propriety of pounding the molds he replied that this was the common custom among cement manufacturers who wished their cements to test well. Can you give me some information on this subject through the columns of Engineering News?

The crux of our correspondent's inquiry lies in the question: What is allowable practice in filling cement briquette models? At first thought the answer would seem to be plain, but the further one studies into the matter the less certain he is likely to be of his ability to formulate an offhand answer. In America the most common practice in making neat cement tests doubtlessly is to use a plastic paste and to fill it into the mold by pressure of the trowel and fingers, but this is by no means universal practice. Many cement testers prefer to use mechanical pressure to compact the cement into the molds, and there are several machines in the market for this purpose. Some of these machines act by direct pressure and others by hammer blows. Turning to mortar mixtures, we shall discover that it is quite common practice to tamp the mixture into the mold, sometimes using a tamping stick and mallet and sometimes a molding machine to get the briquette dense and compact. In Germany it is the universal practice to use dry pastes and mortars and to tamp them into the mold with considerable energy. French practice is to mold neat cement without pressure, and to tamp mortar mixtures. The comparison could easily be extended were it necessary, but what has been said is sufficient to show that while we may assume to define with some degree of certainty what prevailing practice is, we shall at once get into deep water if we attempt to define allowable or permissible practice. If, for example, the question were to come up in a court of law, "experts" could readily be found to espouse either side.

The second phase of our correspondent's question, whether or not it is customary for manufacturers to seek high test results by molding their test briquettes under pressure is less important. It is quite possible and certainly would be exceedingly natural, that for certain record or trade purposes, manufacturers should strive to get as high figures as possible by manipulating the tests to that end. Certainly, however, manufacturers do not regulate the quality of their product by such false standards; they make cement which they may rely upon to meet specification requirements when subjected to ordinary methods of testing.

The important lesson to be drawn from the conditions that have been cited, is this: Cement specifications should stipulate both the tests that are to be made and the manner of making these tests as well as the test requirements desired. It is a very simple task to do this; a brief statement that the tests shall be conducted according to the rules laid down by the American Society of Civil Engineers' Committee on Uniform Tests of Cement will accomplish the result.

An excellent illustration of the extensive field for trained judgment in engineering design is to be found in the subject to which the following letter relates:

> A discussion arises between A and B concerning steel lattice bars of columns. A states that they are more likely to be strained in tension than in compression. B states that compression is by far the more important stress to which they will be subjected. Will your valued paper kindly enlighten us on the subject, and tell us if there is any literature on the subject?
>
> Very truly yours, M. W. D.
>
> Troy, N. Y., Nov. 26, 1904.

The design of the latticing or lacing of columns calls for a good deal of skilful guessing. Structural steel work in general is far closer to theoretical analysis than most other kinds of engineering work, and the design of columns is, in this respect, not much behind truss or beam design. Yet we find that so important an element of the steel column as lacing-bars is only in small part amenable to "theory," but requires the application of good judgment for its proper determination. The same thing applies to many details of structural work, and, of course, much more strongly to the details of most other branches of engineering.

We prefer to consider a problem like that of lacing-bars along the lines indicated in the following: Let us take the case of an I-shaped four-angle column, for example. Suppose we have a centrally-loaded column carrying no shear. In such a column the calculable stressing of the lacing-bars, once the column is erected, is zero. But if we imagine strips of paper or thin sheet-iron in place of the actual lacing-bars, we conclude that a certain amount of strength and rigidity is necessary in these bars. The column must be fabricated, transported and repeatedly handled before it is in its erected position. Even after erection it may be subject to lateral blows, etc., which should be distributed to the ends by the lacing. These various considerations indicate that the lacing is called upon to withstand forces by no means negligible in amount.

It will appear reasonable, from considerations like those outlined, to provide heavier lacing-bars for heavy than for light columns; the riveting and general handling puts stress into the lacing about in proportion to the weight of the column. Moreover, since we know that the lacing must hold the column in line of stress despite the unavoidable departure from mathematical straightness and uniformity of the flanges, we should assume that the required size of lacing varies with the designed column-load. Similarly, it should vary with the spread of the column, and with the angle of the lacing, and would be less for double than for single lacing.

Further, note that columns are rarely or never loaded centrally as has just been assumed. Any excess of loading on one half of the column is transmitted in part to the opposite half, by means of the web members, which in this case are the lacing-bars. The probable amount of excess loading on one side is wholly a matter of guess. Butted column joints between successive lengths are usually a trifle untrue, which throws the larger part of the load to one side in the upper portion of the lower column. Beam connections are not always symmetrical, and, even when intended to be so, their actual loadings at any one time will be different. Here again half the excess of one side must go through the lacing-bars.

All the various attacking forces above indicated must be estimated by guessing, aided, of course, by trained knowledge of actual circumstances and conditions. When thus put into figures, the size of lacing-bars for a given column is readily computed. Comparison with usual practice will then be profitable, and often very instructive.

When the column has to resist a measurable amount of bending moment, as is true in most cases, then the lacing must evidently be made strong enough to transmit the maximum horizontal shear corresponding to this moment. In this case the lacing required will usually be large enough to make it unnecessary to consider the previous suggestions.

Coming now to reply to the question asked in the above letter: It will be clear that in all the matters here suggested the compressive strength of the lacing-bars is taxed as much as, or more than, the tensile strength; for, the lacing constitutes a web-system of the triangular or Warren type. Since the bars are thin, and hence are "long columns," their column strength will govern.

Again, it ought to be remembered in designing lacing-bars, as in nearly all structural work, that all metal surfaces are likely to waste more or less by corrosion. A reduction of ⅛-in. by corrosion will reduce by one half the strength of a member ¼-in. thick, while it will take only one-fourth from the strength of a half-inch thick member. The matter of corrosion, together with the various other matters that affect structural work generally, must, of course, be given due consideration in addition to the special points previously suggested.

Literature on lacing-bars is too scanty to call for mention here. The same remark applies to a large number, perhaps the majority, of those engineering problems where guessing, rather than exact computation, must supply the basis for design.

Accurate and authoritative figures for the cost of maintenance of highways are very scarce, and for this reason the following figures, taken from the November "Nineteenth Century" and credited to the Local Taxation Board for England and Wales are well worth record.

Class of road.	Miles.	Annual cost per mile for maintenance.
A	16,202	$327
B	10,913	531
C	7,325	283
Total	34,440	

These figures refer to the main roads in England and Wales, all presumably being macadamized. Class A embraces main roads under City Councils; class B, main roads under Urban Councils and under Urban and Rural District Councils conjointly; class C, main roads under Rural District Councils. Beside these main roads there are 95,205 miles of other roads under Rural District Councils, the cost of maintaining which averages a little over $100 per mile per annum.

In Aitkin's admirable book, "Road Making and Maintenance," the costs of road maintenance in England and Scotland are given by counties, together with data on the price of road metaling per ton. Aitkin's work was written in 1900, and the figures of cost are somewhat lower than the above figures for the fiscal year 1901-2.

It is noteworthy that thus far in this country the cost of maintaining macadam roads has averaged much less than in England in spite of higher wages. To account for this fact there are four possible factors: (1) Better stone; (2) better methods of construction and repair; (3) less travel; and (4) difference in climate. Just how much weight may be assigned to each one of these factors we do not know. It may come as a surprise to those who still hold the name of Macadam as a synonym for all that is best in road making, to hear the superiority of English road making questioned, although it should be well known that Macadam's original methods are seldom followed abroad except, perhaps, in the matter of repairs. Yet there are good grounds for believing that American engineers have now little to learn from their English cousins in the art of road making and maintenance. With macadam roads in Massachusetts averaging about $100 a year for maintenance it is apparent that American engineers who, a few years ago, were citing English precedent as an argument against stone roads, must modify their views or their arguments.

Many of our readers will remember the discussion in these columns a year ago respecting the relative resistance to corrosion of wrought-iron and steel. An interesting bit of evidence on the matter has just come to our notice from West Australia, where a large part of the water supplies carry more or less salt or alkali. It is stated that boilers for West Australia are now generally made of Yorkshire iron and last about three times as long as the boilers made of steel plates, which were formerly used.

BLOCK SIGNALS AND RAILWAY ACCIDENTS.

An attack upon the block signal system as being unnecessary, ineffective, and subversive of discipline is a curious subject for a paper before a railway club, yet this was the purport of a paper presented last week by Mr. Slason Thompson at the December meeting of the Western Railway Club at Chicago. The paper criticised the accident statistics of the Interstate Commerce Commission, stating that they were not only misleading, but were intentionally made so, to excite the public mind against the railways and aid the Commission to obtain power to compel the use of the block system. The author made the astonishing claim that the number of casualties due to accidents on American railways is not proportionately greater than on English railways, and does not increase in greater ratio than the increase in traffic. He also made the no less surprising statement that with competent and faithful men, overwork is not a cause of danger; and here he is so clearly in the wrong, that he will find very few railway officers, we are sure, to agree with him. A man may, of course, work occasionally for very long hours without impairing his efficiency; but human nature imposes its limitations on both faithful and careless men, and a man who has been continuously at work for 16 to 20 hours, or, as sometimes happens, much longer, is not physically or mentally fit to meet an emergency.

In his attack upon the block system, Mr. Thompson stated that in his opinion the absence of safety devices has very little to do with safety in operation, and that "recklessness, negligence and disobedience in the human equation are mainly to blame for railway accidents." In another part of his paper he admitted that he approved of block signals wherever practicable and where they will "ensure public safety without overburdening public traffic," while in the next sentence he said: "The inevitable tendency of the block signal system is to beget carelessness in the train crews, as it shifts responsibility to the signal system operators or to the signal itself."

If this were so it is hard to see why Mr. Thompson should favor the system at all.

As to discipline, it is well known that English railway employees (working exclusively under the block system) are less prone to disobey orders and signals or to take chances, than are employees on American railways. This is largely due to the fact that for years the former have been trained to implicitly observe and obey signals as their main guidance in running the trains.

It was further stated by Mr. Thompson that the officials of the Board of Trade who investigate and report upon British railway accidents are inspired only by a desire to add to the safety of railway operation and are not intent upon imposing "onerous and impractical burdens" on the railways, the implication being that the Interstate Commerce Commission has such an intent.

The statement as to the Board of Trade is true enough, but it should also have been stated that in England the use of the block system is compulsory, and that no railway can be opened for traffic until its works and equipment (including signals and interlocking plants) have been inspected and approved by the railway department of the Board of Trade.

Mr. Thompson ought to have explained what sinister motive prompts the authorities of the Interstate Commerce Commission in their endeavor to hasten the adoption of the block system by railway managers! Surely he must know, as every intelligent man versed in railway matters knows, that the adoption of the block system has been urged by progressive railway managers in the United States for a quarter of a century; that there is not an authority on railroad engineering who does not favor its use; and that the Interstate Commerce Commission's recommendation is in close accord with enlightened public opinion as voiced by the technical press and by the leading signal engineers of railways.

The fact is that Mr. Thompson's paper expresses the opinions of a certain small class of railway operating officials who have been brought up under the train order system, have been accustomed to it all their life long, who are familiar with its every detail and who cannot adjust their minds to understand and appreciate the advantages of anything so radically different in principle as the block system. The prevalent opinion among men of this type is that the block system is perhaps well enough on a double-track system, but that on a single-track road an alert train dispatcher can keep trains moving all along the line by keeping the wires hot with train orders, whereas with the block system trains will be held up by the signals, train delays will be increased and the capacity of the road for traffic will be reduced.

If there are those among our readers who hold such views or who hear such views and desire to meet them with a "knock-down" argument, we commend to their careful perusal the paper published in this issue describing experience with block signals on the single-track Vandalia line. This paper is written, not by a block signal expert or signal engineer, but by an experienced train dispatcher, who knows what excellent records in the safe movement of trains can be made under certain conditions, with the train order system.

He shows that the block system on the Vandalia has not only prevented accidents but accelerated the movement of trains, reduced the train delays and enabled better average time to be made. He presents detail figures which show that the Vandalia line handled the enormously heavy passenger traffic to and from St. Louis this season under the block system with a substantial increase in the average running time over the record for the same period in 1903, when the block system was not in use and the number of passenger trains run was less by a quarter. This increased speed has been partly due to the increased confidence felt by train crews in the certainty of their protection and partly to the reduction in time spent waiting on sidings.

This is not theory; this is the result of practical experience. Nor is this the only practical experience which Mr. Thompson and those who hold his views would do well to ponder. During the same months while the Vandalia was carrying, without accident, the huge World's Fair traffic delivered to it by the eastern lines of the Pennsylvania railroad system, there were other railways which were attempting to handle similar crowded traffic in the old way and which met with disaster after disaster. Recall for example those terrible collisions on the Missouri Pacific a few months ago. Such things as these are unanswerable arguments for a safer system of train movement.

Mr. Thompson may promulgate his opinions as much as he pleases, but unless he can show American railway managers something better than the block system, his attempts to stem the tide in its favor are as futile as those of the lady who plied her broom to sweep back the ocean.

LETTERS TO THE EDITOR.

Information Wanted Regarding the Early History of the American Society of Mechanical Engineers.

Sir: Twenty-five years ago a small party of engineers met in the office of the "American Machinist," then in a building still standing on the corner of Fulton and William streets, in New York City, and took the preliminary steps toward the formation of an engineering organization which body became the American Society of Mechanical Engineers. It has been decided to prepare, in commemoration of this anniversary, a history of the origin and development of the society; and this work, which has been placed in the hands of a special committee, is already well under way. In order that the records of the beginnings of this important professional organization may be made as complete as possible, it is especially desired that any of those who attended that early meeting, held on February 16, 1880, or who were in any way interested in that early work, may send to the committee any memoranda, correspondence, or other matter of interest relating to that gathering, or to the events which immediately followed.

The committee has already been favored with much efficient help from various members of the society in connection with its work, and as the preliminary work must now soon be brought to a close, it is hoped that this communication may bring additional material for its use.

Communications may be addressed to the Historical Committee, American Society of Mechanical Engineers, 12 West Thirtyfirst St., New York. H. H. Suplee.

New York, Dec. 20, 1904.

The Proposed Combination of the Massachusetts Institute of Technology and Harvard University.

Sir: In connection with the proposed combination of the Massachusetts Institute of Technology with Harvard University the following authoritative statement of foreign opinion (translated from Zeitschrift des Vereines deutscher Ingenieure" of Sept. 24, 1904) is of interest:

"At a meeting of the Union of German Engineers, held at Munich, Sept. 12, with the participation of 30 eminent representatives of technological schools and universities, as well as of other schools and of industries, the following resolutions were adopted:

(1) It is not advisable, so far as can be foreseen, to attempt to meet the need of new technological schools by the addition of technological faculties to universities, but rather by the establishment of independent institutions; for the technological schools would be hindered in their independent development by attaching them to universities. This separation should not, however, impede the welcome development of intellectual good will between the two institutions. The attachment to universities would also in no way involve economies of consequence.

(2) The Union of German Engineers stands now, as before, by its expression of 1886, as follows:

"We declare that the German engineers have the same needs and will be subjected to the same judgment as to their general culture as the representatives of other professions based on higher scientific education."

In this view we rejoice as the conviction more and more gains ground that a considerably greater significance is to be attributed than before to mathematical and natural science as a means of culture. Knowledge of these branches is becoming more and more an indispensable constituent of general education. The predominantly linguistic education now received by the majority of our

gymnasium graduates does not satisfy the demands which must be made on the leading classes of our people, in particular, in respect to the increasing significance of economic questions. Tech. Graduate.

Boston, Dec. 17 1904.

Computation of Cost of Freight Transportation.

Sir: The article on the subject of "Comparative Cost of Fast and Slow Freight Service," published in your issue of Dec. 1, no doubt found many interested readers, especially among those concerned in the economical operation of trains. Perhaps few took the trouble to do any figuring for themselves as I did in the matter of fixed charges.

It is surprising to notice how these are made out for each train. In the first place, it is evidently intended that the fixed charges on rolling stock in a year shall equal 10% of the cost, 5 for interest and 5 for depreciation. The unit charge of 12 cts. made by the author of that article "on each train for each engine (of the 1500 class) for each hour *in transit*" proves to be that charge necessary to be made against that engine for each and every hour of the year. It is to be remembered that no locomotive works every hour in the year and that an engine can earn its fixed charges only while at work. Therefore, if we should find the engine working but half the time, and charged for at the same rate per hour as if it worked continuously, I imagine we would find it earning but half as much as intended, so far as fixed charges are concerned. If all other charges against a train should be made in the same way, at the same rate per hour while in transit (and then only) that would be necessary to be made for each and every hour of the year, it would not require until eternity to break the road up.

The object of the author of the article referred to is, of course, not defeated by an error of that sort, yet the curves shown in connection therewith, one at least, will be somewhat altered. That change is, of course, readily understood. Yours truly,

W. E. Miller.

Chicago, Ill., Dec. 12, 1904.

The Difference in Expansion of Concretes and Steels.

Sir: I have been a close observer of the subjects mentioned in your journal, and more especially of the communications and illustrations concerning reinforced concrete, and I have been anxiously watching for the failures. As a matter of fact, I am not yet able to understand just where the difference in expansion and contraction is going to be taken care of. That there is a difference, there can be no mistake, and it certainly seems to me that there is bound to be some trouble when it takes place. But not having heard of any trouble, I naturally infer that there has been none.

Respectfully yours, P. F. Barr.

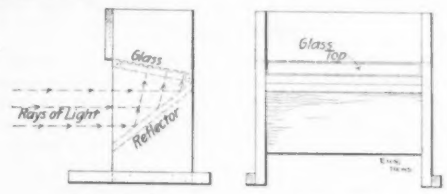
Phoenix, Ariz., Dec. 10, 1904.

(The fact that a large number of reinforced concrete structures have been exposed to the weather in severe climates for years without any indication of injurious effect from thermal changes is sufficient proof that if there is any difference in the rates of expansion for steel and concrete it is not enough to be of consequence. The most recent determination of the coefficient of expansion of concrete is that made by J. A. Rae and R. E. Dougherty of Columbia University, aided by Professor Hallock of the Department of Physics. Prof. Wm. H. Burr, M. Am. Soc. C. E., states that it is believed that this determination was made with the utmost accuracy attainable at the present time in an unusually well equipped physical laboratory and under most favorable conditions. According to this determination the coefficient of expansion for a 1 Portland cement, 3 sand and 5 gravel concrete is 0.000,006,55 per degree Fahrenheit. The mean result of a large number of determinations made at the Watertown Arsenal in 1887 gives the coefficient of expansion of steel as 0.000,006,466 per degree Fahrenheit. The difference between these two figures is $0.000,006,5 - 0.000,006,466 = 0.000,000,034$. In view of the records of experience this difference hardly need cause anxiety as to "where the difference in expansion and contraction is going to be taken care of."—Ed.)

Tracing Drawings by the Aid of Light from Beneath

Sir: A drawing may be traced through very heavy paper by holding the sheets against a window pane, and viewing them in such a manner that they are between the eye and the source of light. One has only to perform the experiment to appreciate its value as a time saver in the transfer and the comparing of drawings. The transparency method also affords ready means for the arrangement of view, titles, lettering, etc. Lettering should first be outlined upon strips of waste paper, one word to each strip of paper. The separate word strips can be shifted between the drawing and the glass until the most pleasing arrangement is secured. Then the lettering may at once be traced on to the drawing without the necessity of ruling guides and space lines.

A convenient transparency modeled after a photographer's retouching frame is outlined in the accompanying sketch. Any carpenter can make one in a few minutes' time.



End Elevation. Front Elevation.

In use, a piece of opaque cloth is thrown over the draftsman's head, the cloth allowed to fall about the frame so as to cut out all light except the rays that pass through the glass. A "stop," or sheet of black paper the size of the glass with a hole cut out of this paper just large enough to cover the area to be traced, will intensify the transparency effect. With this device one can easily trace through two thicknesses of heavy muslin-backed drawing paper.

As a rough and ready expedient for camp use, I have frequently placed a light in the bottom of a big dry goods box, or an empty cement barrel. By covering the open top with a piece of glass (usually from a blue print frame) a transparency is extemporized, which, although not an artistic piece of furniture, serves its purpose very well. Outside light can be shut off by means of a black cloth, and the transparent effect may be localized by employing a paper stop, as already described.

Yours truly, Ralph E. Parker.

"P Ranch," Burns, Oregon, Dec. 10th, 1904.

The Balancing of Engines.

Sir: The solution of the problem of balancing an engine, to which, in connection with the paper by Mr. S. B. Moss, you devote an editorial in the current issue of Engineering News, was first given with exactness fifteen years ago by Prof. D. S. Jacobus, and may be found in Vol. XI., page 492, of the "Transactions of the American Society of Mechanical Engineers." The title of the paper is: "General solution of the transmission of force in a steam engine, as influenced by the action of friction, acceleration and gravity."

I believe that the reciprocating motor has been made in the past as well as it ever will be made in the future, and that no more attention could be given to the matter of balancing than has been given to it in the past. It is a pity that the catalogue of the "Transactions" is not consulted oftener by those who write academic papers for the consumption of new members.

It would be a source of pleasure to be able to share your belief in the final survival of the reciprocating engine. Certain steam turbines now in existence are far from perfect, it is true, but I cannot escape the feeling that it has been sufficiently demonstrated that, for the generation of large powers, especially for railroad work, the outlook for the reciprocating type of prime mover is dark. In fact, I personally hold that the steam turbine, all things considered, has utterly killed the reciprocating machine already. Yours truly,

George I. Rockwood.

62 Summer St., Worcester, Mass., Dec. 16, 1904.

(We give space with pleasure to the above note regarding Prof. Jacobus' paper, which we find on examination to cover a considerable broader field than treated by Mr. Moss.

Perhaps our correspondent is right that engine builders could do nothing more to accurately balance their engines than they have already done; but if we mistake not, in a large proportion of the engines now running, crank counterweights, if used at all (as they frequently are not on slow-speed engines), are proportioned by the roughest sort of approximation of rotating weights without taking reciprocating parts into account. In locomotive design, practise is much better, because the locomotive has not the advantage of a heavy masonry foundation to absorb the vibrations due to its unbalanced parts; yet even here it is only within very recent years that an earnest effort has been made to reduce the weight of reciprocating parts and thus the hammer-blow effect upon the rail, and it is still more recently that the merits of the four-cylinder balanced locomotive have been conceded by practical men.

As for the competition between the steam turbine and the reciprocating engine, even if the former proves its superiority (as it seems likely to do) in driving electric generators and centrifugal pumps, there are many other uses to which the steam engine is harnessed, involving large power at slow speed, ready reversal of motion, etc., where the applicability of the turbine is, to say the least, yet to be demonstrated. It is difficult to imagine a steam turbine hoisting engine or blooming mill engine, for example. In marine work, a distinguished steam turbine designer is on record as doubting its adaptability even for high speed vessel propulsion, and for slow speed vessels it is still more doubtful how it could compete with the present efficient machinery.—Ed.)

Notes and Queries.

A correspondent asks what effect will too much salt in masonry mortar (lime and gravel) have? Would you suggest 1 lb. of salt to every 18 gallons of water and an extra ounce for every degree below 32°?

If any of our readers have had any experience in using salt in lime mortars we should be glad to have them give us an account of it.

B. T., Atlanta, Ga., writes:

A discussion has arisen concerning the proper method of allowing for the weight of a locomotive on a track parallel to and back of a retaining wall, the track being within the space betwen the top of the back of the wall and the angle of repose of the fill made against it. Will you or some of your readers elucidate the matter.

The problem referred to is a common one and any of the standard treatises which consider retaining wall design explain also the method of providing for loads upon the filling behind the wall. For a live load producing considerable jarring, such as railway trains, the surcharge will produce a greater pressure against the back of the wall than that due to a quiescent load of equal amount, such as a building foundation, for example. Allowance for this is a matter for careful judgment, taking into consideration the material of which the fill is made, rather than for numerical computation.

THE RELATION OF MOSQUITO EXTERMINATION TO ENGINEERING.

A paper with the above-named title was read in New York on Dec. 16 before the American Mosquito Extermination Society by Mr. C. C. Vermeule, Consulting Engineer, of New York City.

After referring to the well-known relations between mosquitos and malaria, the author stated that within a radius of twelve miles of the city hall in New York there is a population of 4,000,000 scattered over a total area of 362 sq. miles, of which 62 sq. miles or 40,000 acres are marsh land. With the rapid increase in the population of this district the marshes become more and more of a nuisance and danger, because the inhabited areas are nearer to them and because the waters become more polluted with city wastes.

The 27,000 acres of marsh land bordering the Hackensack and Passaic Rivers might be reclaimed by diking, sluicing and, if necessary, pumping, thus affording industrial sites of great value, as well as reducing mosquitos and malaria and increasing the general healthfulness of the section. Prior to the utilization of the reclaimed land for manufacturing and shipping it could be devoted to market gardening and dairying. In 1896-7 Mr. Vermeule reported to the New Jersey Geological Survey that for a capital outlay of $50 an acre, or say $7 per acre per year for capital charges, maintenance and operation, these marshes could be rendered dry enough for agricultural purposes. Thus utilized the land would pay carrying charges until needed for other purposes.

In contrast to the possibilities of a comprehensive scheme, as outlined, small portions of these and other marsh lands are being filled in piecemeal. The work is not always properly done and the adjacent "unimproved" land contains more stagnant water than before. United action by public drainage districts or by private corporations is needed.

To be effective, the ground water level should be established and maintained at a depth of 1½ to 3 ft. below the surface of the ground. This affords aeration of the soil and prevents or makes it possible to prevent the accumulation of rainwater in pools. Shallow ditches in marsh lands afford uncertain, temporary relief.

Summarizing his arguments, Mr. Vermeule said:

(1) As a measure for exterminating mosquitos, it is a

striking truth that if these lands should be reclaimed at public expense and then restored to their present owners without cost, beyond a pledge to maintain them in good condition, and the cost should be paid by issuing 30-year bonds, the interest and sinking fund charges being assessed upon the taxpayers of the district, the cost to the average family would be less than the sum now expended for window and door screens, mosquito canopies, lotions, etc., while the resulting improvement to the health and comfort of the community would be above all price.

(2) As a measure for enhancing the value of real estate on the uplands adjacent to the marshes, the enterprise would be worth far more than its cost.

(3) The new property created by the reclamation of these 40,000 acres of waste land may be conservatively estimated at over $10,000,000 above the cost of the improvement.

(4) The population, manufacturing and commerce which could be accommodated in the future about the bay and harbor of New York would be greater by fully one-fourth.

THE CONCRETE-STEEL WATER TOWER AND STAND PIPE AT FORT REVERE, HULL, MASS.*

This structure, the author stated, was the first water tower in this country to be constructed of reinforced concrete. It is situated on the summit of Telegraph Hill, 150 ft. above sea level, within the military reservation. In 1902 the department prepared plans and specifications for a steel stand-pipe and an enclosing tower, the latter being intended both to protect the tank from freezing and to give a pleasing architectural effect. In advertising for proposals, bidders were asked to submit proposals for either stone or brick masonry tower on the department's designs, or for a tower and stand-pipe from their own designs and specifications. The proposal accepted was that of R. Baffrey of New York, for a concrete-steel tower and stand-pipe on the Hennebique system. Work was begun in June, 1902. The concrete work was finished that fall, but the contract was not wholly completed until June, 1903. The stand-pipe has been in constant use since its acceptance in June, 1903, and has given perfect satisfaction. It has never leaked, and no seepage through its walls can be noticed.

The tower is octagonal in form, 33 ft. across the base and 84 ft. high to the apex of the pyramidal roof. It consists principally of reinforced concrete, but the deeply recessed panels on the sides are of buff pressed brick. The winding stairs extending to the observatory above the stand-pipe are also of reinforced concrete. The roof is of wood, covered with slate. The foundation course is of 1:3:5 Portland cement concrete, extending only below frost, since it is founded on the "hard-pan" or glacial drift. A part of the concrete foundation is occupied by a valve chamber 5 × 9 ft. in plan and 6 ft. high. The walls of the tower are 4 ft. thick at the base, with vertical faces to a height of 4 ft., above which the outer faces batter to a thickness of 2 ft. at 11 ft. above the floor, where there is a belt course 2 ft. thick. The external faces of these lower walls are divided by deep grooves into rectangles, giving the appearance of coursed masonry. The concrete in this part of the tower is reinforced by ¼-in. steel rods. Eight reinforced concrete columns, 38 ft. in height, rest on these base walls and carry a coping upon which the concrete floor of the observatory rests. The spaces between the columns are filled with the brick panels previously mentioned.

The stand-pipe, which is the most interesting portion of this structure, is 20 ft. in diameter and 50 ft. high, containing about 118,000 gallons. The walls are of concrete, 6¼ ins. thick at the base and 3¼ ins. at top, strengthened by steel rods embedded in the concrete. On the inside there are three coats of Portland cement plaster, having a total thickness of 1 in. The concrete was mixed in 1:2:4 proportions. The steel rods forming the horizontal reinforcement are ½-in. in diameter at the base, with two rings in each horizontal plane, the vertical distance between rings being 1¾ ins. At the top there is but one ring in a plane and the vertical spacing is 7½ ins. The reinforcement of the body of the tank is completed by 5-16-in. vertical rods wired to the rings at points of contact, and spaced 8 ins. apart. In the bottom are two systems of ½-in. rods crossing at right angles, spaced 4 ins. apart. The junction between the bottom and the sides is strengthened by ⅜-in. rods, 3 ft. 4 ins. long, placed radially, about 8 ins. apart. The cost of the tower and stand-pipe complete was about $12,000.

*Based on a paper read by Mr. Leonard S. Doten, C. E., Quartermaster's Department, U. S. A., before the monthly meeting of the New England Water-Works Association, Boston, Dec. 14. The paper will be printed in full in the "Journal of the New England Water-Works Association."

BREAKING TEST OF A 16 × 2-IN. EYE-BAR FOR THE QUEBEC BRIDGE.

A graphic illustration is furnished by the accompanying half-tone engraving of the enormous dimensions of the eye-bars now being forged at Phoenixville, Pa., by the Phoenix Bridge Co., for the 1,800 ft. cantilever span of the Quebec Bridge. The bar shown is 16 × 2 ins. in the body and has a head 36 ins. in diameter and an eye 14 ins. in diameter. This bar was tested to destruction in the 1,200-ton testing machine at Phoenixville, giving the following results: Ultimate tensile strength, 52,450 lbs. per sq. in.; elastic limit, 30,650 lbs. per sq. in.; elongation in 7 ft., 22.3%; elongation of pin-hole, 6.8 ins.; reduction of area at fracture, 43.1%. The bar broke in the body and showed about 50% silky fracture. For the information from which this description has been prepared we are indebted to the Phoenix Bridge Co., Phoenixville, Pa., the contractors for the Quebec Bridge superstructure.

View Showing 16 x 2-in. Eye-Bar for Quebec Bridge Broken in 1,200-Ton Testing Machine of Phœnix Bridge Works.

A NEW PROPOSAL FOR A DAM ACROSS THE RIO GRANDE, NEAR EL PASO, TEX.

After years of controversy over interstate and international water rights and over rival projects harmony is now reported in the matter of the proposed dam near El Paso, Tex. This dam would stretch across the Rio Grande River to the Mexican shore and would affect irrigation interests in Texas, New Mexico and Mexico.

Harmony is attributed in part to the recent National Irrigation Congress at El Paso, but apparently it is really grounded, at least so far as Texas and New Mexico are concerned, on a new project, better suited to the needs of all concerned. Before the passage by Congress of the National Irrigation Act a careful reconnaissance of the Rio Grande valley near El Paso was made by Mr. A. P. Davis, M. Am. Soc. C. E., now Assistant Chief Engineer of the U. S. Reclamation Service. This was early in 1902. One of the objects of the study was to determine the relative merits of the International and the Elephant Butte projects.

Mr. Davis reported in favor of a larger reservoir than would be afforded by either scheme and pointed out a feasible site near Engle, N. M. On the organization of the Reclamation Service, Mr. F. H. Newell, M. Am. Soc. C. E., Chief Engineer, caused surveys of the Engle site to be made by Mr. J. A. French, and recently plans for a dam and studies of the available water supply have been completed by Mr. B. M. Hall, M. Am. Soc. C. E. At the El Paso Irrigation Congress these plans were explained by Messrs. Newell and Hall and, it is stated, met with the approval of the representatives from the Rio Grande Valley.

The foregoing statements are based on a circular letter issued by Mr. Guy E. Mitchell, Secretary of the National Irrigation Association,* and approved (in a private letter to this journal) by Mr. Davis. Mr. Mitchell describes the project of the International Dam Commission, and summarizes the report of a board of consulting engineers on the relative merits of the International and the Engle dams as follows:

INTERNATIONAL DAM COMMISSION.

The International Commission, composed of U. S. Army Engineers and Mexican Engineers appointed by that government, in its report recommended that the United States should buy all necessary land, pay all damages and construct at American expense the international dam at "the pass," about four miles above El Paso; submerge 25,565 acres of good land in the United States, extend the Mexican boundary up stream to the dam site, ceding Mexico 98 acres additional territory in order that one end of the dam might be on Mexican soil; deed one-half of the dam, the reservoir, and the water supply to the Republic of Mexico forever, and prohibit the construction of any large reservoir on the Rio Grande in New Mexico.

The alternative plan suggested by the U. S. Reclamation Service is to build a storage dam opposite Engle, N. M., across the Rio Grande at a point about one-quarter of a mile below the site selected by the old Elephant Butte Co. From this reservoir it is proposed to irrigate 180,000 acres of land; 110,000 acres being in New Mexico, 20,000 acres in Texas, above El Paso, and 50,000 acres in the El Paso valley below El Paso. There will be little good land submerged by this reservoir. It will be located in New Mexico, and subject to the operations of the U. S. Reclamation Service, while the International dam, which contemplates only the irrigation of 55,000 acres of land, would be owned jointly by two nations.

BOARD OF CONSULTING ENGINEERS, U. S. RECLAMATION SERVICE.

The following is a summary of the results of an investigation recently held by a board of consulting engineers on the designs and estimates for the proposed International and Engle dams:

(1) The proposed Engle reservoir has a capacity of 2,000,000 acre-feet, as against about 500,000 acre-feet that can be provided by the proposed International reservoir at El Paso.

(2) The Engle Reservoir will furnish for irrigation 600,000 acre-feet of water per annum, while the International will furnish only 80,000 acre-feet.

(3) The Engle will lose no water by overflow while the International will waste a very large part of the inflow.

(4) With a given amount of water the Engle will present only one-half the surface for evaporation that will be presented by the International.

(5) Silt deposits will accumulate with almost double rapidity in the International as in the Engle.

(6) The Engle reservoir is deep and narrow, while the International reservoir is wide and shallow; any process of sluicing out mud will be nine times as efficient in the former as in the latter.

(7) The Engle reservoir will store the entire flow of the river without waste and with a minimum evaporation and will prevent disastrous floods along the valley occupied by several important towns and by the Santa Fe railroad, while the International reservoir will waste the water by overflow, present conditions producing a maximum of evaporation, regulate no floods above El Paso, cover 25,000 acres of good land near El Paso and make marsh land of 15,000 more acres above it and produce unsanitary conditions at El Paso.

(8) The International dam proposes to destroy 40,000 acres of good land immediately north of El Paso, in order to irrigate about 55,000 acres below El Paso; while the Engle reservoir proposes to irrigate the 40,000 acres of land that the other would destroy and to irrigate 50,000 acres below El Paso, and in addition to irrigate 90,000 acres above in New Mexico, a total of 180,000 acres, all of which is tributary to El Paso.

The estimated cost of the Engle dam and reservoir and of diversion works and canals above El Paso is $7,200,000. This sum would impound 600,-

*1419 F St., N. W., Washington, D. C.

000 acre-feet, sufficient to flood 180,000 acres to a depth of 3½ ft., and would also provide main canals for carrying the water to 110,000 acres of land in New Mexico and 20,000 acres in Texas. The estimates do not include the canals necessary to divert water from the river for use on 50,000 acres below El Paso. The dam is the main item in the expenditure. Some 300,000 bbls. of cement would be required for its construction.

In conclusion, we may note that Mr. Mitchell's letter is silent as to the features of the new project which led the Mexico delegates at the Congress to join in "harmony and jubilance" amounting almost "to a love feast." Under the International project Mexico was to be deeded, the circular letter states, "one-half of the dam, the reservoir and the water supply." Under the Engle scheme, so far as our information goes, Mexico is granted no rights whatever.

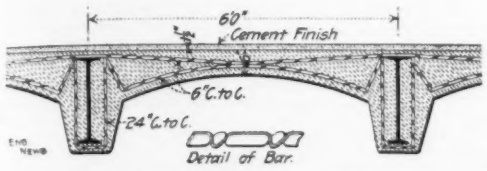


Fig. 1. Arched Slab Floor of Reinforced Concrete, Metropolitan Building.

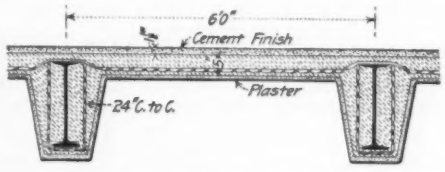


Fig. 2. Flat Slab Floor of Reinforced Concrete, Metropolitan Building.

REINFORCED CONCRETE SLAB FLOORS FOR THE METROPOLITAN BUILDING, NEW YORK CITY.

The accompanying illustrations show the reinforced concrete slab floor construction for the 16-story annex of the Metropolitan Building, now being constructed on East 24th St. in New York city. There are altogether some 90,000 sq. ft. of this floor. Fig. 1 shows the style of construction adopted for the first floor and sidewalk and Fig. 2 shows the plain slab construction for the upper floors. The slabs are constructed of 1:2:5 cinder concrete reinforced by De Man bars, which are 1 × ⅛-in. steel straps crimped at regular intervals to the form shown by the enlarged detail in Fig. 1. The location of the reinforcement in the vertical plane is clearly shown by the drawings. In the horizontal plane the rods are set parallel to each other at distances apart varying from 6 to 12 ins. depending on the loading. The plain slab floor construction has passed the standard fire and water test of the New York Building Department and previous to adoption by the architects of the Metropolitan Building a 4-in. slab of 6 ft. span was subjected to a load test. The load was applied at the center and broke the slab at 40,699 lbs. The floor is controlled by the American Fireproofing & Cement Construction Co., of New York city.

PLANS FOR NEW GRAND CENTRAL STATION, NEW YORK CITY.

An official statement was given out to the press this week regarding the New Grand Central Station, which is to be built in New York City, to replace the present building at 42d St. and Fourth Ave. As our readers are aware, work has been in progress for many months on the transformation and enlargement of this terminal for the use of electric locomotives, and the better accommodation of traffic. With the statement was issued the architects' sketch of the proposed new station. We present it herewith and reprint the substance of the official description of the station as follows:

The plans for the new terminal in New York City involve the use of an area of more than 19 city blocks between 42d and 57th Sts., Madison and Lexington Aves.

The station proper, together with the post office and express buildings, will cover the blocks between Vanderbilt and Lexington Aves. from 45th to 43d St., inclusive, and the block fronting on 42d St. between Vanderbilt Ave. and Depew Place.

The buildings will be set back from 42d St. a distance of about 40 ft., and back from Vanderbilt Ave. a distance of about 70 ft., so as to afford a generous approach to the station and give the effect of 140 ft. open space on the 42d St. frontage and 130 ft. open space on the Vanderbilt Ave. frontage.

The frontage of these buildings will be 680 ft. on Vanderbilt Ave., 625 ft. on 45th St., 460 ft. on Lexington Ave., 275 ft. on 44th St., 260 ft. on Depew Place, and 300 ft. on 42d St.

In addition to the public streets, there will be connections by ample private roadways and walks to Madison Ave. on the west and Lexington Ave. on the east; thus giving the traveling public facilities for entering the station not only from 42d St. on the south, Vanderbilt Ave. and Depew Place, but from Madison Ave. on the west and Lexington Ave. on the east.

The suburban trains will be on a lower level than the express trains, thus separating the commuter from the express passenger and affording better facilities for both. The suburban concourse will provide for nine tracks. The express concourse will be slightly depressed below the street level and will provide for 22 passenger train tracks, two baggage tracks, two mail tracks and eight express tracks, making 43 tracks in all, with platforms so connected by subway and elevators that baggage, mail and express may be quickly transferred without crossing the tracks.

The main entrance to the station is on 42d St. Its architectural composition is three massive arches, each arch being 33 ft. wide and 60 ft. high. Beyond these arches one enters an enormous ticket lobby 90 ft. × 300 ft. This ticket lobby is on the level with the street. On the right of this lobby, and practically a part thereof, is the outgoing baggage room. After purchasing one's ticket and checking one's baggage, one proceeds to the express train by entering a gallery overlooking the grand concourse and thence to this concourse, which is on the level of the express tracks. This concourse is approached by four grand staircases, each 25 ft. in width. This concourse is the largest in the world, being 160 × 470 ft., and 150 ft. high, with wide entrances at each end and extending to Madison and Lexington Aves. Adjoining this concourse are the usual waiting rooms, retiring rooms, cafés, telephone and telegraph facilities, etc. The waiting rooms contain twice the area of the waiting rooms in the Grand Central station as it is at present. Through this concourse pass the departing and arriving passengers, but the arriving passengers are absolutely separated from the departing passengers, thus avoiding the usual confusion in a railroad station caused by the meeting of incoming and outgoing passengers. From the concourse one goes to the trains in the train room. The platforms are of ample width, averaging from 15 to 18 ft. wide, whereas the narrowest platform of the present station is but 8 ft. wide and the widest is but 12 ft. wide. This liberal width of platforms affords ample facilities for quickly leaving the train and avoids the usual crowding. The suburban train room has a splendid feature for quickly emptying the trains and avoiding crowding, by having platforms on either side of the train. These platforms are even wider than the express platforms, ranging from 17 to 29 ft. in width. The concourse end of all express platforms have the additional advantage of being free from the handling of baggage.

The exit from the station is along Vanderbilt Ave., approached by ample staircases. To the north and along Vanderbilt Ave. is the incoming baggage, conveniently placed for arriving passengers. The company's cab stand is on the level of the concourse and the express tracks. In the provision for this cab stand the railroad company has been more than generous, allowing more space than would be contained in Fifth Ave. between 33d and 34th Sts. if the avenue were twice as wide as it is at this point. The cab stand may be reached with equal facility by the suburban and the express passengers.

Besides the main entrances and exits before described there are additional entrances and exits for the suburban passengers, so that the commuter need not enter the main part of the station, but can go directly from the street to the train or from the train to the street by an easy incline, avoiding all staircases. There is provided at the express level a connection with the subway. There is also an entrance and exit to the station by way of an incline from Madison Ave., enabling the cab or foot passengers to approach or leave the station at the west end of the grand concourse. At the subway level there is provided a subordinate concourse with ample waiting and retiring rooms. At this level there is provided a loop for quickly dispatching the suburban trains and provision has also been made for a possible connection with the rapid transit system. There has been a further provision for pipe galleries in 42d St., Vanderbilt Ave. and Depew Place, with means of easy access thereto without disturbing the public highways.

The baggage room adjoins Depew Place, 45th St. and Vanderbilt Ave., with 1,300 ft. of street frontage and 47,000 sq. ft. of floor space, sufficient to care for baggage in rush seasons without the delay in delivery now experienced at all large stations.

The express concourse and waiting rooms are so situated that suburban passengers can use them if desirable, and these accommodations are so placed that from the standpoint of facility in handling the passengers either tier of tracks may be used interchangeably.

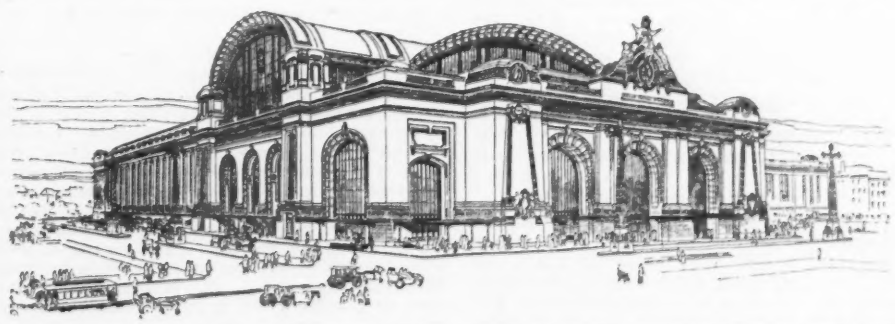
There is ample space for the handling of incoming and outgoing baggage.

The approaches and departures from the station are on the company's own property.

To the north of the concourse and carrying the cornice line of this monumental part of the building, around the entire building, are placed the company's offices, containing about 250,000 sq. ft. in area, exclusive of corridors, elevators, etc., with entrances at the two corners of the building at 45th St. and Park Ave., and with ample elevator facilities leading to the concourse itself. These offices are built around a court, thus providing light for each office and providing for splendid natural light in the higher part of the train room.

Provision is made for doubling the capacity of the station without in any way interfering with the architectural features or general plan of the station.

The architects of this station are Warren & Wetmore, associated with Reed & Stern, of New York City.



PERSPECTIVE SKETCH OF PROPOSED NEW GRAND CENTRAL STATION, NEW YORK CITY.

THE FAMOUS PENNSYLVANIA-WESTERN UNION case has been decided by the U. S. Supreme Court in favor of the railway company. The Western Union Telegraph Co. contended that it could maintain its lines on the right-of-way of the railway company because an Act of Congress gives them the right of eminent domain on all post roads. The Pennsylvania R. R. Co. some time ago refused to renew its contract for telegraph service with the Western Union Telegraph Co., and ordered the latter to remove its lines. The telegraph company failed to do so, and the railroad company cut down the telegraph company's poles along hundreds of miles of line. Suit was brought by the telegraph company, and the decision now reached determines that telegraph companies do not have the right of eminent domain on railway lines.

A SMALL GASOLINE-ENGINE LOCOMOTIVE has been brought out by the German gas-engine builders Deutz & Co. The machine is suitable for use as a mine, logging or yard locomotive. It is a four-wheel affair of 20-in. gage and 16-in. wheels carrying a frame of steel channels. On the frame is mounted a horizontal gasoline engine with a cylinder 6 ins. × 9½ ins. A 40-in. flywheel on the engine-shaft overhangs the truck-frame. The engine works on the four-stroke cycle and runs at 300 r. p. m. normal speed, under control of a flyball governor. Oil is supplied by a small pump driven off the crank shaft, and the ignition is by electric spark. The exhaust is discharged by way of two muffler chambers fitted under the floor. The cooling water is circulated from the cylinder through a radiating chamber, thence back to the cylinder, by means of a pump. The rotation of the engine shaft is transmitted to the axles by way of an intermediate shaft. The engine-shaft is geared to the intermediate through a reversing friction coupling, and the intermediate drives the axle by a sprocket-chain. Another sprocket-chain couples the two axles. The locomotive weighs about 2½ tons, ready for service.

THE VENTILATION OF THE HARBOR PORTION OF THE EAST BOSTON TUNNEL.

The complete system of ventilation of the Boston Subway for electric cars has been extended to the tunnel extension under Boston Harbor, which was recently opened for traffic. As in the land portions of the subway resort is had to direct ventilation by exhaust fans. To review briefly: the land sections of the subway carry either two tracks or four tracks which occupy cross-sections of 332 sq. ft. and 707 sq. ft., respectively. The exhaust fans are set in chambers adjoining the tunnel and located about midway between stations. They take the air from the tunnel and discharge it upward, generally through grated openings in the street sidewalks, but in two cases they discharge through low shafts or stacks. Fresh air enters at the stations and flows each way to the fans.

The arrangement of the ventilating apparatus for the tunnel under the harbor is quite clearly shown by Figs. 1 and 2. The construction is described as follows in the last report of the Boston Transit Commission:

A duct to be used in ventilating the tunnel extends from near Webster St. in East Boston to and under the harbor and to the Atlantic Ave. station. It has a cross-section of about 48 sq. ft., and is formed in the upper part of the tunnel by means of a diaphragm 1 in. thick made of expanded metal enclosed in cement mortar. This diaphragm is attached to the tunnel walls by steel rods and plates which are themselves encased in concrete. A partition midway between the two ends divides the duct into two portions. On each side of the partition there are 14 openings each 4 ft. long and 1 ft. 5 ins. wide in the flat portion of the duct; and at intervals of about 550 ft. there are other groups of openings, diminishing in number as they approach the fan chambers. These openings are fitted with doors which can be opened or closed from the tunnel below. When the movement of the air in the tunnel is not affected by wind only the two groups of openings close to the middle partition will be kept open. When the movement of the air is so affected the various openings will be used in such a manner as best to promote the even ventilation of the different parts of the tunnel.

Fresh air will enter the tunnel from the portal at East Boston and through the station near Atlantic Ave. This air will move to near the middle of the tunnel and pass through the openings into the duct referred to above. The air will then be drawn to the east and west and will leave the tunnel at the fan chambers at Atlantic Ave. and at Lewis St. in East Boston. A diagram rudely indicating the movement of the air is given on Fig. 1. The duct, illustrated by Fig. 2, was built during the first three months of 1904. A section 335 ft. long was first built directly by the Engineering Department for experimental purposes.

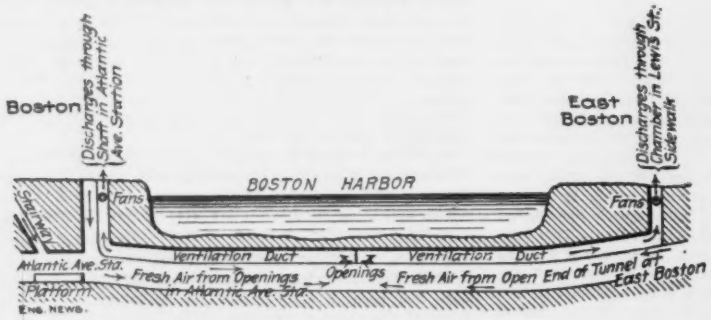


FIG. 1. DIAGRAM SHOWING CIRCULATION OF AIR IN VENTILATING THE EAST BOSTON TUNNEL.

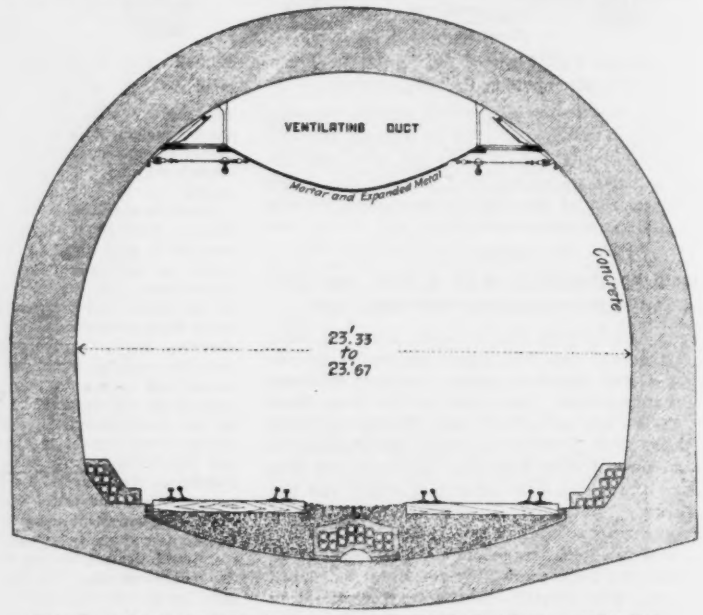


FIG. 2. CROSS-SECTION OF EAST BOSTON TUNNEL, SHOWING VENTILATING DUCT.

A WATER-WORKS TUNNEL and a pipe line is being built for the city of Santa Barbara, Cal. The tunnel will extend for 19,560 ft. through the Santa Ynez Mts. to the Santa Ynez River and will be 5 ft. wide at the base 3½ ft. wide at the top, and 7 ft. high. Construction was begun on April 18, 1904, and will be completed in about five years. The tunnel will cost $230,000. A reservoir on the Santa Ynez River is proposed, with a storage capacity of 18,000 acre-feet or some 5,500,000,000 gallons. The water developed in the tunnel during its construction will be piped to the city for use prior to the completion of the tunnel and reservoir. A contract for pipe for a pipe line from the tunnel to the city distributing reservoir was awarded to J. D. Hooker & Co., on Nov. 9, 1904, as follows, the prices being for Converse lock joint pipe: 2,400 ft. of 11-in., 95 cts. per ft.; 3,700 ft. of 9-in., 69½ cts.; 10,000 ft. of 6-in., 41 cts. These prices are for pipe f. o. b. at Santa Barbara. The contract for the pipe-laying, including all labor for the pipe in place, was awarded to Boescke, Dawe & Co., of Santa Barbara, Cal., at 14.3 cts. per ft. Pipe-laying will be started about Jan. 1. For the information given we are indebted to Mr. Lee M. Hyde, Engineer Water-Works Department and City Tunnel Construction.

BIDS FOR THREE WAR VESSELS for the U. S. Navy were opened in Washington, D. C., on Dec. 15. The lowest aggregate bids were 11 per cent. less than bids for three sister ships a year ago. Contracts were awarded to the lowest bidders: Two 14,500-ton armored cruisers, "Montana" and "North Carolina," to the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., at $3,575,000 each; the 16,000-ton battleship "New Hampshire" to the New York Shipbuilding Co., Camden, N. J., at $3,748,000. The times of completion specified by the bidders were 36 months and 38 months, respectively.

THE EFFECT OF A SNOWFALL ON REMOVING bacteria from city air was observed on Dec. 3, 1904, and is reported by Dr. Arthur Reynolds, Commissioner of Health of Chicago, in his circular for the week ending Dec. 10. Bacterial cultures were made on the date named, after a light snowfall, and are compared with similar cultures made on two previous dates, when there had been no fall of snow. The counts were made on plate areas of 10 sq. ins. each, exposed for one minute. The results of the three series of counts were as follows:

Place.	Height,* ft.	Number of bacteria.† Nov. 26.	Nov. 29.	Dec. 3.
La Salle and Washington...	10	107	120	19
	0	950	846	16
Clark and Madison.....	8	670	714	24
	0	1,020	986	23
State and Washington...	10	124	141	20
	0	106	134	12
Clark and South Water...	0	965	940	19
State and Washington...	130	100	91	18
	130	98	103	12

*Of exposed plate above the level of the street.
†After light fall of snow.

A COMPETITION FOR POTENTIAL INDICATORS has been called by the French Association des Industriels contre les Accidents du Travail, acting for the Ministry of Commerce, Industry and Communication. The object of the competition is to secure an apparatus which will indicate in simple manner whether a conductor is charged; the purpose of this is to reduce the list of accidents arising from contact with live wires, cables, machines, etc. A committee of ten was appointed by the Association to prepare general specifications for such an instrument and prepare for the competition. A sum of 6,000 fr. ($1,200) was assigned for prizes. The principal conditions laid down for this instrument in the program of competition are:

The instrument is intended for use by all persons who work on or near electrical conductors, to enable them to learn whether contact with the conductors is dangerous. It must be hardy, portable, easily handled, insensible to atmospheric and other changes. It must involve no accident or risk of damage to operator, to the conductors and electric system in question, or to the instrument itself, and the service on the system must not be disturbed. It must be applicable equally to high and low tension current, direct and alternating, to underground and aerial conductors. After previous notification to the Association, accompanied by detail description and drawings, any instrument intended for the competition must be held ready, on June 1, 1905, for shipment to a point of test which will be designated by the committee. The Director of the Association, 3 Rue de Lutece, Paris, may be addressed.

A REAR COLLISION IN PARIS, France, on Dec. 23, 1904, killed at least six passengers. A dense fog was responsible for the collision, which occurred just outside the North Station. The rear car of the forward train was crushed.

A SERIOUS BUTTING COLLISION on the Southern Ry. occurred on Dec. 25, 1904, at Brown's Crossing, Ill. Two through passenger trains, eastbound and westbound, running between St. Louis, Mo., and Knoxville, Tenn., collided because a train order for the passing was not delivered to the eastbound train. The operator at Brown's Crossing, it is stated, had displayed the train order semaphore stop signal, but just before the train arrived someone meddled with the signal and cleared it. The train went by without orders and the collision resulted, as both trains were beyond the last telegraph station where a stop order could reach them. Seven persons were killed outright in the wreck, and several others were fatally injured.

SMOKE IN A CLAY MINE caused the death of seven men by asphyxiation on Dec. 22, 1904. The accident occurred in a mine of the Reese-Hammond Fire Brick Co. at Bolivar, Pa. A small storage shanty near the mouth of the mine caught fire, and the smoke was drawn down the air-shaft, a short distance away. The escape of the men in the mine was cut off by the burning shanty, and before rescue could reach them five were dead and two others so far gone that they died shortly afterward.

ROLLER BEARINGS FOR CAR AXLES have been ordered by the London, Brighton & South Coast Ry., of England, for the equipment of one of its passenger trains, after two years' experimental service on a car which has run 80,000 miles. Greater ease in starting a train and fuel economy due to the reduction in journal friction are among the advantages claimed. The journals are 4 × 8⅝ ins., and on each journal is tightly fitted a sleeve of hardened steel 7-16-in. thick, finished by grinding. Outside of this is a similar but larger sleeve, and in the annular space between the sleeves are 14 rollers of case hardened steel, ground to a finish. The rollers are ⅞-in. diameter and 8 ins. long, and are held in a lantern or cage which prevents them from coming in contact with each other; this lantern revolves slowly around the journal. The axle boxes are about the same size as those for the ordinary bearings. These roller bearings were made by the Empire Roller Bearing Co., of London, and are in experimental use on electric street cars in England.

TALL BUILDINGS IN GERMANY have many advocates, among them the German Industrial Association. The latter recently appealed to the government to revise its position concerning the limits placed on height of buildings, with a view to making possible the erection of tall buildings on the American model. The government, however, refused to consent to such revision, on the ground that no reasons for the step had been brought forward sufficient to counter-balance the arguments of safety, health and aesthetics on which the limit of height is grounded. The present limit in the city of Berlin is 22 m. (84 ft.).